Assessing the Adaptive Capacity of the Ontario Wine Industry to Climate Change
A Case Study

By

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Abstract

The global wine industry is experiencing the impacts of climate change. Canada's major wine sector, the Ontario Wine Industry (OWI) is no exception to this trend. Warmer winter and summer temperatures are affecting wine production. The industry needs to adapt to these challenges, but their capacity for this is unclear. To date, only a limited number of studies exist regarding the adaptive capacity of the wine industry to climate change. Accordingly, this study developed an adaptive capacity assessment framework for the wine industry. The OWI became the case study for the implementation of the assessment framework. Data was obtained by means of a questionnaire sent to grape growers, winemakers and supporting institutions in Ontario. The results indicated the OWI has adaptive capacity capabilities in financial, institutional, political, technological, perceptions, knowledge, diversity and social capital resources areas. Based on the OWI case study, this framework provides an effective means of assessing regional wine industries' capacity to adapt to climate change.

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Chapter 1

Introduction

Anthropogenic induced climate change is a complex and dynamic phenomenon the impacts of which are being experienced throughout the world (Adger & Barnett, 2009; Füssel, 2009; Rosenzweig, Casassa, Karoly, Imeson, Liu, Menzel et al., 2007; Smith, Schneider, Oppenheimerd, Yohe, Haref, Mastrandreac et al., 2009). Initial climatic predictions of a 2^{o}C rise in global mean temperatures over the next century have recently been revised with this increased to a 4^{o}C rise (Adger & Barnett, 2009; Smith et al., 2009). At 2^{o}C spontaneous adaptation was expected to occur. At 4^{o}C adaptation is less certain due to the expectation of bio-geographical thresholds being breached causing irreversible changes that could threaten the planet's ecological life support systems (Adger & Barnett, 2009). The International Panel on Climate Change (IPCC) recognizes the need for adaptation and strongly encourages governments, industries and businesses to focus on adaptation efforts alongside present mitigation strategies (Adger et al., 2007).

Adaptation is a continual process of change and adjustment by an individual, group, sector or nation to modify negative impacts and exploit new opportunities (Brooks, 2003; Smit et al., 2001). Adaptations may occur as minor or major alterations, which happen spontaneously or as planned actions to reduce the negative impacts of a stimulus, such as an extreme weather event (Smithers & Smit, 1997). The process of adaptation is heavily influenced by the pre-existing ability of a system to change in response to a stimulus, called its adaptive capacity (Engle, 2011). Not all systems have

the same adaptive capacity. Those with greater resources have greater capacity and are more likely to adapt than those with less (Yohe and Tol, 2002). The resources identified affecting adaptive capacity include finance, institutions, policies, technology, income diversity, knowledge, and social capital (Armitage, 2005; Brooks, Adger & Kelly, 2005; Gupta, Termeer, Klostermann, Meijerink, van der Brink, Jong et al., 2010: Marshall & Marshall, 2007; Plummer & Armitage, 2010; Smit et al., 2001). The interactions between resources and the social processes that support their mobilization are also significant factors influencing capacity (Nelson, Adger, & Brown, 2007; Tol & Yohe, 2007). Consequently adaptive capacity is spread unevenly across, and within societies, it changes over time and is influenced by local and broader social factors (Yohe & Tol, 2002). Assessing the adaptive capacity of a community or sector offers a lens to better understand the process of adaptation and helps to explain why some areas adapt more successfully than others.

The agricultural sector is directly impacted by changes in weather and climate. Recent shifts in growing seasons, increasing frequency and intensity of extreme weather events, and new areas for production have been identified within the sector. The wine industry has been one of the first areas to document climate related production changes. It is considered the 'canary in the coal mine' in the context of climate change due to the narrow geographic and climatic range required by many grape varieties. Present climatic shifts have been identified as responsible for reducing wine quality and quantity in some areas and expansion of the wine growing acreage in other areas (Mira de Orduña, 2010; Maaβ & Schwab, 2010; Ramos & Martinez-Casasnovas, 2010). Other studies have indicated a shift in growing seasons and changes in production areas (Webb, Whetton, &

Barlow, 2010). To date, climate change research on the wine industry has largely focused on documenting climatic trends and modelling future climate in existing wine regions (Jones, 2007; Ladányi, Hlaszny, Pernesz, & Biszztray, 2010; Malheiro, Santos, Fraga, & Pinto 2010; Vuković, Vujadinović, Djurdjević, Ranković-Vasić, Marković, Atanacković et al. 2010). Other studies have identified present and future climatic impacts and more recently adaptive strategies focusing on the sustainability of the industry (Kenny, 2010; Saint-Ges & Bélis-Bergouignan, 2009; Schwab & MaaB, 2010). The recent focus on adaptation is more evident in places experiencing negative climatic impacts, including Europe (Jones 2010), California (White et al., 2006), Australia (Webb et al., 2008), and Canada (Belliveau et al., 2006). The importance of adaptive capacity has been recognized as evidenced by research conducted on individual capacity components, such as perception and water access (Alonso & O'Neil, 2011; Ballangini et el., 2009; Belliveau et al., 2006). These studies suggest a more comprehensive analysis of the adaptive capacity of the wine industry is required (Kenny, 2010; Holland & Smit, 2010).

The Ontario wine industry (OWI) is an established, profitable and growing industry within Canada, accounting for over 80% of Canada's wine production and contributing over $3.8 billion annually in direct and in-direct revenue (Frank, Rimmerman and Co, 2013). In 2010, there were over 15,000 acres of vineyards and more than 130 wineries producing 15.6 million litres of wine (Grape Growers of Ontario, 2012). The industry is experiencing several challenging impacts of climate change, such as an increase in the risk of winter freeze injury through warmer winter temperatures that disrupt cold acclimation of the vine, an increase in the frequency of winter freeze thaw events, a decrease in the protective snow cover and a reduced harvest period for ice wine.

Other impacts include weather related diseases and harvest failure due to wetter and warmer growing seasons along with an increase in pests (Cyr, & Shaw, 2010). In other respects higher summer temperatures are negatively affecting the established cool climate varieties. Some studies have indicated the presence of higher alcohol levels and reduced wine acidity due to greater summer temperatures (Cyr, & Shaw, 2010; Shaw & Cyr, 2010). Adapting to these impacts is critical if the industry is to continue to expand and maintain consistent quality. The Canadian and Ontario governments recognize the need for adaptation within agriculture and are developing policies related to long-term planning for water shortages, supporting research for drought resistant crops, and monitoring plant pests (Government of Canada, 2010; Ontario Ministry of Agriculture and Food and Rural, 2011). No specific policies are in place for adaptation to climate change within the wine industry. However, support for research on this issue was demonstrated in the recent success of the Ontario Research Fund: Research Excellence fund Round 5. This broad based project highlights the interest within the OWI for adaptation in bringing together researcher and industry members to collaboratively develop strategies for the industry to adapt over the next 30 years. The OWI is preparing to adapt to climate change, adaptations are recognized as a product of adaptive capacity. In this context this study poses the following questions:

- How can the adaptive capacity of the OWI be assessed?
- What is the present adaptive capacity of the OWI?

Answering these questions provides a unique opportunity to assimilate scholarship from such critical areas as climate change adaptation, adaptive capacity, viticulture and

oenology literature in order produce a conceptual assessment framework. This also provides a heuristic device to guide the assessment of adaptive capacity in the OWI.

1.2 Objectives

The general objective of this study is to assess the adaptive capacity of the OWI in adapting to the impacts of climate change. The following are the specific objectives of this research.

Objective 1. To provide a critical review of the climate change literature relevant to adaptive capacity, oenology and viticulture in order to develop a framework to access the adaptive capacity of the OWI.

Objective 2. To empirically assess the adaptive capacity of the OWI using the adaptive capacity framework developed in this study.

1.3 Thesis Organization

The thesis is organized into five chapters. The first chapter provides the rationale for this research and identifies the research questions and guiding objectives. Chapter two summarizes the scholarly literature that informs this work. It begins with climate change and the international wine industry. The conceptual basis of adaptive capacity, from which the conceptual framework is developed, is then explored. Chapter three outlines the methodological approach and research design employed in this study. This includes an overview of the case study method, the context-specific details regarding the chosen

case study, and a detailed description of how the research was conducted and the limitations.

The fourth chapter presents the findings of the research and discusses them in context of scholarly literature. The results are presented in three parts. The first presents the results and discusses them with reference to each of the eight determinants. The second section conveys the outcome of the comparison analysis and discusses the determinants collectively. The third section provides the results of the analysis based on the grower and winemaker responses. Finally chapter five offers conclusions and recommendations for the OWI and discusses future research.

Chapter 2

A Review of Climate Change Impacts on the Wine Industry and the Significance of Adaptive Capacity.

Chapter two summarizes the scholarly literature that informs this research. The chapter is divided into three sections. First is a review of the academic literature documenting the impacts of climate change on the global wine industry. The second section briefly summarizes the concepts of adaptation, vulnerability, resilience, and adaptive capacity. The third section presents an integrated assessment framework based on the concepts of the previous two sections.

2.1 Climate Change and the Wine Industry

The production and consumption of wine is part of human history and cultural heritage. The earliest evidence of wine production dates back to 7000 BC (Phillips, 2000) and has expanded globally to many geographical locations. The two main limiting factors for wine production are climate and culture (Phillips, 2000). Wine production is an industry driven by consumer demand. Present market trends for the international wine industry are for the production of quality wines from *Vitis vinifera* grapes (Fraser, Slingerland, Ker, Fisher, & Brewster, 2009). These grapes have a narrow optimal growing temperature range from 12^{o}C - 24^{o}C for quality wine production and are very susceptible to damage from cold temperatures (Jones, 2010). A strong dependence on temperature has given the wine industry the position as the 'canary in the coal mine' for climate change. The industry is already experiencing changes in the quantity and quality

of wine production in many regions as a result of climate change (Duchene & Schnider, 2005; Mira de Orduña, 2010; Webb et al., 2010).

The following literature review begins by explaining the effect of temperature on the grape vine and resulting fruit quality. This is followed by a summary of the impacts climate change is having on wine production and present management strategies. A more in-depth exploration of two management strategies examples is then given to illustrate how external factors influence their implementation and effectiveness.

2.1.1 Impacts of Climate Change on the Wine Industry.

While soil and topography are important factors for wine production, temperature is the most dominant and restricting element (Jones, 2010). Overall a temperature range of 12-24^{o}C is required for *Viti* vinifera grapes. Each variety within this family has an even narrower optimal growing temperature range. Grapes are grown at optimal temperatures in order to produces quality juice. With adequate wine making skill, quality wine can then be produced. When temperatures are below or above optimal levels this is reflected in the juice quality and resulting wine, and consequently in wine sales and profit for the industry. Temperature controls when the growing season begins and ends; when veraison occurs (when the grapes change colour and accumulate sugars); enzyme action within the grape; development of flavonoids, seeds, skin colour; and ripening of the grape (Jones, White, Cooper, & Storchmann, 2005; Mira de Orduña, 2010).

Increasing temperatures have been documented in most of the global wine growing regions resulting in an earlier growing seasons, decrease in time to veraison and earlier harvest times (Duchene & Schneider, 2005; Jones et al., 2005; Webb et al., 2007; Rosenzweig et al., 2007; Schultz & Jones, 2010). The effect of this increase in

temperature has created optimal growing conditions in some regions, resulting in an increase in wine quantity and quality (Jones, 2010). The warmer temperatures have also expanded the industry into regions that historically have been too cold for quality wine production such as Britain and the Netherlands (Alonso & O'Neill, 2011). Unfortunately, the 1.3^{o}C increase in the global mean temperature over the past 20 years has also resulted in a decrease in quality wine production in three major global wine producing countries: Spain, the United States of America and Australia (Alonso & O'Neill, 2011). Predicted temperature increases over the next 50-100 years are expected to move the optimal temperatures for wine production poleward and to coastal areas and higher elevations (Schultz and Jones, 2010).

When temperatures move beyond the optimal range during the growing season, grapes and vines continue to grow and ripen but with a reduction in grape juice quality. Growers and winemakers select grape varieties that suit their geographical location and growing temperature range to produce quality wine. Counties such as Germany, Canada, and New Zealand, with cooler growing temperatures, favour varieties such as Chardonnay, Riesling, and Pinot Noir. Australia, Chile, Spain and California where temperatures are warmer favour varieties such as Syrah, Cabernet Sauvignon, Zinfandel. As temperatures continue to increase over the next 50 years the suitability of varieties for many established regions are expected to change (Jones, 2010).

The most destructive and difficult to manage impacts of climate change for the wine industry are the increasing frequency and intensity of extreme weather events. The most commonly experienced damaging weather events, their implications for wine production and present management responses are summarized in Table 2.1.

Table 2.1 Extreme weather events and impacts on wine grapes and wine quality

Extreme weather event	Effect on quantity	Effect on quality	Management Response
Increase in summer temperatures	Higher sugar concentrations (Dokoozlian & Kliewer, 1995; Jones & Davis, 2000).	Increase in alcohol level reducing acidity (Jones & Davis, 2000).	Pick grapes earlier. Reduce sugar concentration before fermentation (Pickering, Heatherbell & Barnes, 1999).
Extreme rainfall at harvest (>30°C)	Dilutes flavour and sugar (Soar, 2005; Jones & Davis, 2000). Increase disease such as mildew.	Reduced flavour and increased bitterness of the wine (Wollan, 2010).	Crop insurance. Distillation in the winery. Dealcoholisation techniques for wine (spinning cone column (Wollan, 2010).
Extreme rainfall in early spring	Increased risk of downy and powdery mildew.	Poor flavour development.	Crop insurance.
Increase in freeze thaw events	Vine becomes more prone to freeze damage, may come out of dormancy too early.	Reduced quantity. Reduced acidity (malic acid). Buds are killed with cold temperatures.	Crop insurance. Add tartaric acid during winemaking process. No management available.
Drought	Reduced berry size, shoot growth and quantity of juice, stress on the vines	Reduced yield. Less anthocyanin synthesis. Grapes pass through optimal ripeness in a shorter time than can be harvested.	Irrigation. Increase canopy cover to delay ripening.
Increased disease	Reduced vigour, berry size and reduced sugar content in grapes.	Off flavours. Reduced yield.	Open canopies, fungicide spray. No management available.
Increase in pests	Kill the vines, eat buds and grapes.	Reduce in quality of grapes, give off flavours (ladybeetle taint).	Irrigation to cool vines and grapes, shade canopy management, Pesticides (Weaver, 1996). Acetylene exploders for birds remediation of green compounds (Creasy & Lombard, 1993; Pickering, Blake, Solas, & Inglis, 2010).
	Sugar accumulation and metabolic processes may completely stop so grapes do not ripen (Coombe, 1987).	Green flavours in wine, poor quality from immature fruit.	
	Increase in evapotranspiration.	Concentration of sugars increases alcohol content in fermentation.	Irrigation in the vineyard, refer to high sugar concentration solutions above.
	Altered level of flavonoids.	Affects colour, bitterness, mouth feel.	No management available.
	Altered aromatics.	Increased kerosene notes with resiling, reduced overall aromatics of white wine.	
Cold temperature extremes in winter (<-20°C)	Kills the vine.	No yield.	Bury the vines with soil in the fall, irrigation in fall, wind machines.
Last spring and early fall frost	Kills the buds that form the grapes.	No yield.	Use of wind machines, irrigation, helicopters, heaters, heat-blocks, fog machines. Late pruning.
Water stress	Reduces berry size and shoot development.	Unripe fruit.	Irrigation.
Hail	Damages vines and	Reduced quantity.	Crop insurance.

Table 2.1 offers a range of strategies to manage the impacts of extreme weather events. However, it is important to note there are several impacts that have no management responses.

2.1.2 Challenges of Present Extreme Weather Event Management Strategies

There are a variety of management strategies suggested for the various extreme weather events that can affect wine production as listed in Table 2.1. This implies the implementation of a strategy to an event is a simple cause and effect relationship: the weather event causes an impact and the implementation of a strategy reduces the negative effect. However the majority of these strategies are influenced by multiple external factors, which can restrain or prevent their implementation resulting in reduced wine production. Following is a critique of two commonly given management responses from Table 2.1: irrigation and crop insurance.

Irrigation is used in the vineyard during both extreme high temperatures and cold temperatures such as frosts. During cold temperatures water from irrigation is sprayed/dripped onto the vines to form an insulating layer of ice (Gilby, 2005). When temperatures are high irrigation aids in reducing heat stress of the vine (Gilby, 2005). For growers to use irrigation, they must have access to infrastructure to bring water into the vineyard then to the vines. In most of the older growing regions of Europe water infrastructure does not exist as mature grapevines are not generally irrigated and there is limited space for such additions (Alonso & O'Neill, 2011). In places where water infrastructure is available the grower must often have access to water rights. For example, in Australia viticulture must compete with other demands for water allocation including

non-viticulture crops, industry, hydroelectric power generation and urban centres. This has become a very limiting factor for wine production, especially in the Murray Darling Basin (Hadarits, Smit, & Diaz, 2010; Wei, Langford, Willet, Snow, & Lyle, 2011). Within the Murray Darling Basin, higher temperatures and declining rainfall have reduced water levels and increased water demand (Alonso & O'Neill, 2011). This has resulted in significant crop and income losses for farmers (Alonso & O'Neill, 2011). Consequently the water footprint for agricultural production is becoming an emerging issue in many places, most significantly in California and Australia (Schultz and Stoll, 2010). Given the competing demands for water and its reducing availability the use of irrigation as a long-term adaptive strategy may need revisiting and other management practices devised.

The other management strategy, which appears frequently in Table 2.1, is the use of crop insurance. This is a risk management tool employed throughout the global wine industry as a short-term strategy to assist farmers in lessening the negative financial impacts of weather events that result in crop losses (Mahul & Stutley, 2008). In practice, farmers choose their 'worst years' to claim crop insurance, and can receive up to 60% of the estimated crop value (Matheson, 2008). Farmers do not generally claim every 'bad year' so as to prevent elevating premiums and making insurance unaffordable (Matheson, 2008). In the short term, crop insurance has been helpful to allow farmers to manage a 'bad year' and still have enough capital to produce and harvest a crop the following year. As a longer-term management strategy, Smithers and Smit (1997) found that the presence of crop insurance limited changes in cropping practices in Southern Ontario suggesting a reliance on crop insurance could result in a lack of adaptation by farmers.

These examples illustrate the many factors affecting the implementation of management strategies for the wine industry. The potential for these strategies to be detrimental in the long-term adaptation of the industry to climate change has also been identified. While present climate changes are providing optimal growing conditions for many wine regions, the industry has been cautioned that these conditions are expected to be of short duration (Adger et al., 2007; Jones, 2010). The wine industry must strategically plan for future adaptations to keep adapting to the impacts of climate change. Understanding the process and components of adaption will assist the industry to move forward. The following section will summarise the concepts of adaptation, vulnerability, resilience and adaptive capacity.

2.2 The Conceptual Landscape of Climate Change Adaptation and Adaptive Capacity.

This section begins with a summary of the concept of adaptation within the climate change scholarship. A summary of vulnerability and resilience, both cornerstone concepts in the development of adaptive capacity, will be discussed. This will provide the conceptual framework for examining adaptive capacity in this research. Next is an in-depth exploration of adaptive capacity that summarizes its history, defines the term for this research, explains the determinants, identifies previous models and applications, and finally offers a critique of the concept.

2.2.1 Adaptation

Adaptation is a term most commonly associated with the biological sciences and Darwinian theory of evolution (Burton, 2009). In this context adaptation is considered a natural, but passive process occurring spontaneously through random genetic mutations

within a population. As genes mutate individual characteristics change where those most physically suited to the physical environment survive gaining mating partners and dominating the gene pool. Those less suited struggled to survive and mate, with their genes eventually removed from the gene pool over time. This process, known as 'survival of the fittest', focuses on the physical environment without consideration of the many social influences known to affect adaptation and as such become a major barrier to the concept (Burton, 2009). This changed when the United Nations Framework Convention on Climate Change first used the term in relation to climate change (Burton, 2009). This opened the door for further exploration of the concept beyond its genetic beginnings (Burton, 2009). It is within the field of climate change this research is situated and the concept of adaptation is explored and summarised.

The IPCC (2007) define adaptation as: "An adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Adger et al., 2007, p.869). Essentially adaptation is a continual process of change occurring within human and ecological systems. The timing of an adaptation is significant for defining the different types (Smit et al., 2001). These can occur anywhere along a continuum from an autonomous, reactive response to an actual stimuli that may cause short-term, spontaneous adaptations through to a predicted stimulus where adaptive measure can be anticipatory, planned and long-term (Brooks, 2003; Wandel and Smit, 2006). Smit et al., (2000), created an adaptation assessment framework to better understand what adaptation was, why it occurred and how effective it was. The framework consists of the following four questions: (i) adaptation to what?, (ii) who or what adapts?, (iii) how does adaptation

occur?, (iv) how good is the adaptation? These question help to define and categorise specific adaptations but they do not identify the underlying processes affecting the success or failure of the strategies.

In the IPCC Third Report (2003), it was believed countries with the greatest amount of wealth would more easily adapt to climate change impacts. Preventable loss of life in the European heat wave of 2003 and hurricane Katrina in 2005 changed this assumption. These extreme weather events highlighted there were more forces affecting adaptation than access to resources. Primarily, the importance of institutional support and structures for the allocation and mobilization of resources has since been recognized as essential for adaptation to occur (Nelson et al., 2007).

Adaptation within the climate change literature was first understood through the concept of vulnerability. In this context, adaptation occurs in the form of adaptive strategies that are invoked to reduce the vulnerability of a system by decreasing the sensitivity and exposure to a negative stimulus (Brooks et al., 2005; Füssel, 2007). In the last decade the concept of resilience has further informed the adaptation literature and developing the concept (Berkes, Colding, & Folke, 2003; Folke, 2005) Vulnerability and resilience have become the two main conceptual approaches for understanding adaptation within the climate change literature. Each will be briefly discussed in the following sections.

2.2.1.1 Vulnerability

The vulnerability approach to climate change adaptation has its history in hazard management (Engle, 2011). The IPCC (2007) define vulnerability as the "degree to which a system is susceptible to and unable to cope with adverse effects of climate

change, including climate change extremes. Vulnerability is a function of the character, magnitude and rate of climate change and the variation to which a system is exposed, its sensitivity and it's adaptive capacity" (Adger et al., 2007, p.896). It is frequently divided into two categories: biophysical and social (Brooks, 2003; Engle, 2011). Biophysical vulnerability is the amount of damage a hazard may cause to a system and is informed through a risk assessment (Brooks, 2003). The degree of injury sustained is determined by: exposure (type, intensity, frequency and duration of the hazard), sensitivity of the system to the hazard, and the degree a systems adaptive capacity can moderate both exposure and sensitivity (Brooks, 2003; Smit & Wandel, 2006). Social vulnerability is a pre-existing susceptibility to harm resulting from social conditions including poverty, inequality, marginalization and reduced access to resources (Adger et al., 2007). Social and biophysical vulnerability are inter-connected influencing the overall vulnerability of a system. The central theme of vulnerability is to minimize the risk of damage to a system from the physical environment (Engle, 2011).

There has been a great deal of research within the climate change adaptation scholarship to identify and assess the many factors that influence exposure and sensitivity as witnessed by the many vulnerability assessments conducted (Ford, Smit, and Wandel, 2006; Haddad, 2005; Hinkel, 2010; Nelson, Kokic, Crimp, Meinke, & Howden, 2010). Within vulnerability studies, building adaptive capacity has been identified as a significant way to reduce vulnerability (Adger et al., 2007; Engle, 2011; Smit & Wandel, 2006; Yohe & Tol, 2002).

The vulnerability approach to adaptation until recently has dominated the climate change literature (Adger 2006; Brooks, 2003; Gallopin, 2006; Hinkel, 2011; Smit et al.,

2001; Smit & Wandel, 2006). Over the past decade literature on the resilience approach to climate change adaptation has been increasing as an alternative but complementary perspective to vulnerability. The following section briefly summarizes the resilience concept.

2.2.1.2 Resilience

Resilience comes from the discipline of ecology, and was first introduced in the 1973 paper, 'Resilience and stability of ecological systems' by C.S. Holling (Gallopin, 2006). There are three commonly recognised types of resilience: engineering resilience, ecological resilience, and social-ecological resilience. Engineering resilience refers to the speed a system can return to equilibrium following a change or disturbance (Folke, 2006). The focus is on maintaining the constancy of a system, resisting disturbance and change, thereby conserving what has been gained through past changes (Folke, 2006). This focus has dominated past resource management and is implicated in many present-day ecological problems (Berkes, Colding, & Folke, 2003). In contrast ecological resilience considers ecosystems to be influenced by multiple variables and processes, creating many stable states within a system. Resilience is seen as "the amount of disturbance a system can take before its controls shift to another set of variables and relationships that dominate another stability region" (Holling, 1973 cited in Folke, 2006, p.254). Variability is understood as fundamental for existence and learning in a system where surprise and unpredictability dominate is essential (Folke, 2006). Change is seen as a positive force, driving the adaptive process which incorporates constantly shifting levels of equilibrium as the system continues to retain the same functions and structures, identity and feedbacks (Holling, 1973; Walker, Gunderson, Kinzig, Folke, ,Carpenter, &

Schultz, 2006). The process of adaption occurs as systems move continually through adaptive cycles. The adaptive cycle consists of four phases: exploitation, conservation, release and reorganization (Figure 2.3). The adaptive cycle can be explained using the example of a forest following a fire. The first two phases are the time for opportunistic species to establish and grow, consolidating nutrients and biomass to a point of climax (Berkes, Colding, & Folke, 2003). This state of equilibrium is susceptible and ripe for environmental disturbances such as fire. When such an event occurs the accumulated capital is suddenly released giving new opportunities to other species. This is quickly followed by a reorganization period where released nutrients become fixed in other parts of the ecosystem, as the renewal of the forest starts again (Berkes, Colding, & Folke, 2003). It is the reorganization phase of this cycle that provides an opportunity for innovation, learning, and adaptation to occur giving rise to a different forest following each cycle (Berkes, Colding, & Folke, 2003). The cycles vary in scale, space and time and the pathways between the cycles influence the behaviour of the system (Berkes, Colding, & Folke, 2003; Holling, 1982; Walker et al., 2006).

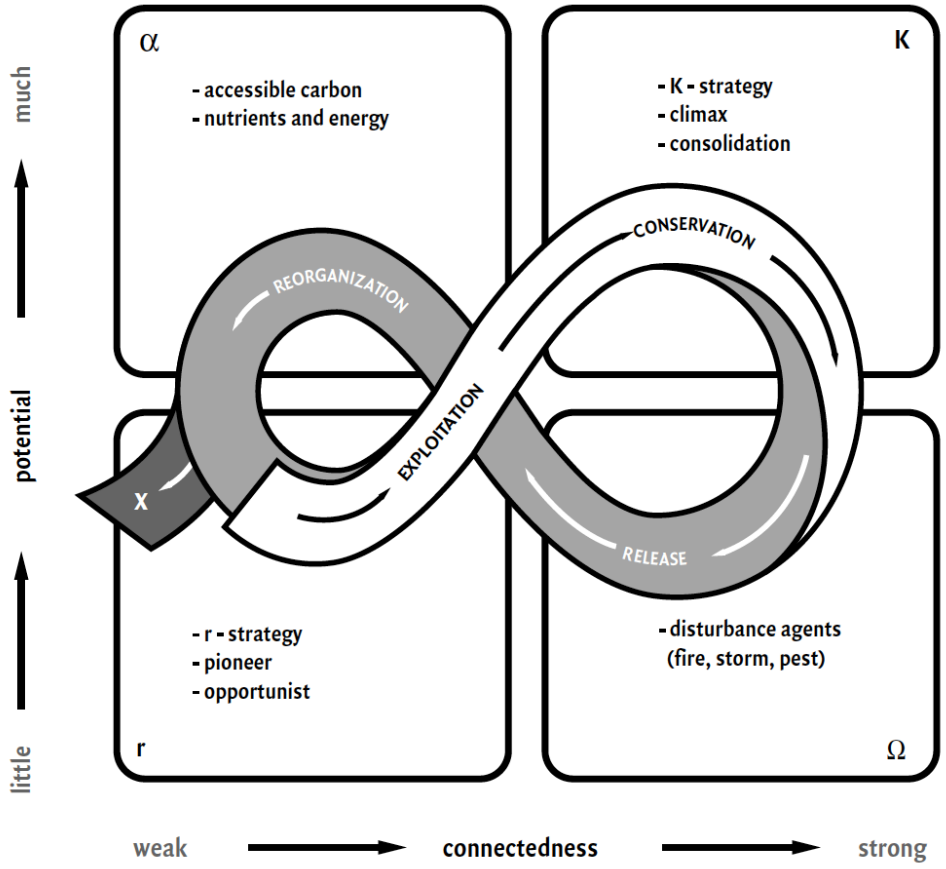


Figure 2.1 The adaptive renewal cycle. Sourced from Berkes, F. Coding, J. Folke, C. 2003. Navigating social-ecological systems: building resilience for complexity and change. Pp.42.

Social-ecological resilience builds upon these ideas and understands that social and ecological systems are linked. These systems are capable of self-reorganization, sustaining and developing with the ability to build and increase capacity for learning and adaptation (Folke, 2006; Gunderson, 2003). The resilience of a social-ecological system is affected by the ability of actors to facilitate and transform in response to disturbance when present systems states are untenable, i.e. their capacity to adapt (Engle, 2011; Folke, 2006).

An element identified as important in both vulnerability and resilience is adaptive capacity (Gallopin, 2006; Smit & Wandel, 2006). There has been an increasing demand

to further explore this concept and the factors that influenced it (Füssel, 2007; Gallopin, 2006; Holland & Smit, 2011; Smit & Wandel, 2006). Engle (2011) offers a new perspective on adaptive capacity seeing it as a link between vulnerability and resilience (see Figure 2.4). Moving it out of the shadows of these approaches provides the opportunity for greater exploration and understanding of the concept and the many factors influencing it. Following is an elaboration of the present understanding of the adaptive capacity concept.

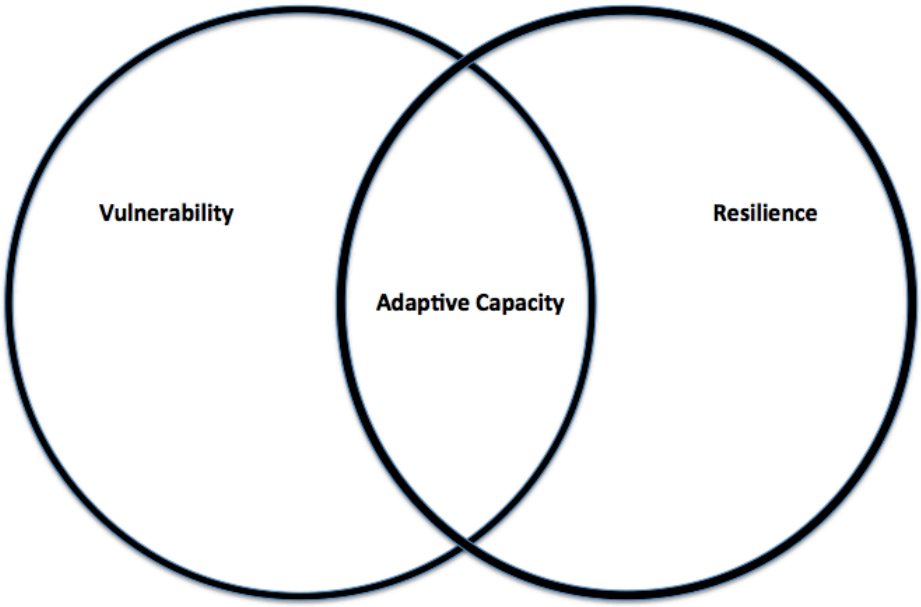


Figure 2.2: Vulnerability and resilience frameworks linked by adaptive capacity. Sourced from Engle, 2011, (p.652) Adaptive capacity and its assessment. Global Environmental Change. 21: 647-656.

2.2.2 Adaptive Capacity

Adaptive capacity is a relatively young concept that has been identified as essential for adaptation to occur (Füssel, 2007; Matthews & Sydneysmith, 2010; Smit & Wandel, 2006). The concept, like adaptation, has an interdisciplinary background and consequently it carries several meanings summarized in Table 2.2.

Table 2.2 Summary of multidisciplinary definitions of adaptive capacity

Discipline	Definition
Natural sciences (Evolutionary biology)	Adaptedness is the fit of an organism to their environment, features that make an organism better adapted to their environment enhancing their fitness.
Social sciences	Broadening cultural repertoire and improving coping methods that foster cultural endurance.
Environment and resource studies: - Political ecology	Concentrates on social vulnerability of people, by emphasizing socio-economic, demographic, cultural, and political characteristics, as well as the role of institutions and governance for shaping vulnerability (Adger, 1998; Cutter et al., 2003). Ability to adapt is influenced by endowments, capability and entitlements. Adaptive capacity affects vulnerability by modulating exposure and sensitivity (Engle, 2011)
- Risk and hazards	Focuses on the possibility of loss (risk) to a system from exposure to a hazard. The intensity, duration, frequency and location of the hazard and the vulnerability of a system determine the degree of risk. Vulnerability is reduced by capacities of individual protection and collective action.
-Resilience thinking and social- ecological systems	The ability of a system to maintain a dynamic balance between sustaining and developing, involves learning to live with uncertainty, nurturing diversity, bringing together multiple knowledge systems and ways of learning and fostering opportunities for self organization. Adaptive capacity emerges out of the systems capacity to tolerate and deal with change through self organization
Climate change studies	"The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages to take advantage of opportunities or to cope with consequences" (Adger et al., 2007, p.869). Adaptive capacity is focused on reducing vulnerability.

Sourced from Plummer & Armitage. 2010.Integrating perspectives on adaptive capacity and environmental governance. in Adaptive capacity and environmental governance, eds. Armitage and Plummer (Springer 2010)

Another definition by Armitage and Plummer, (2010, p.6) takes a broader view of adaptive capacity emphasizing that systems are social-ecological in nature and are affected by many social factors. They define adaptive capacity as "the capacity of a social-ecological system to be robust to disturbance and to adapt to actual or anticipated changes (whether exogenous or endogenous). It is determined by resources (technical, financial, social, institutional, political) held and the social processes and structures through which they are employed and mediated." This definition combines insights from both the vulnerability and resilience literature and provides the definition of adaptive capacity for this research. Within this definition some of the determinants of adaptive capacity are identified, the following section will further explore these and other determinants.

2.2.2.1 Determinants of Adaptive Capacity

There have been many factors identified that influence the adaptive capacity of a system for climate change adaptation. A summary of these determinants is shown in Table 2.3. Reviewing Table 2.3 it quickly becomes apparent there is a great deal of commonality between many of the determinants listed. For example economic/ financial resources are found explicitly or implicitly in all columns. Although each determinant shown appears as separate they are interconnected and work collectively to limit or build adaptive capacity (Matthew & Sydneysmith, 2010). For example, financial resources influence the ability to purchase technology and build required infrastructure.

Table 2.3 Determinants of adaptive capacity

Smit et al., 2001	**Yohe & Tol, 2002 p.26**	**Armitage, 2005**	**Gupta et al., 2010 p.4**	**Marshall, 2010**
Economic resources Technology Information and skills Infrastructure Institutions Equity	Structure of critical institutions and the allocation of decision making authority Range of available technical options for Stock of human capital Stock of social capital System's access to risk spreading Way in which decision makers maintain and distribute information Public's attribution of the source of stress and significance of exposure	<u>Operational:</u> Technical Financial Social Institutional Political <u>Strategic:</u> Power Scale Knowledge Community Culture	Variety Learning capacity Room for autonomous change Leadership Resources Fair governance	Political Technology Cultural Financial Social resilience (perception) Resource dependency Learning

Modified from Matthews R and Syndneysmith R. 2010. Adaptive capacity as a dynamic institutional process: conceptual perspectives and their application. In Armitage, D. Plummer, R. Eds. 2010, Adaptive Capacity and Environmental Governance. Springer, Heidelberg, Germany. p. 226.

Eakin and Lemos (2006) provide yet another list of determinants and further identify the many components include under each (see Table 2.4). There is a great deal of consensus

in this list and those in Table 2.3 indicating many factors are universal across scale and context.

Table 2.4 Adaptive capacity determinants and components

Determinant	Encompasses
Human Capital	Knowledge (scientific, local, technical, political), education levels, health, individual risk perception, labour
Information and Technology	Communication networks, freedom of expression, technology transfer and data exchange, innovation capacity, early warning systems, technological relevance
Material resources and infrastructure	Transport, water infrastructure, buildings, sanitation, energy supply and management, environmental quality
Organization and social capital	State- civil society relations, local coping networks, social mobilization, density of institutional relationships
Political capital	Modes of governance, leadership, legitimacy, participation, decentralization, decision and management capacity, sovereignty
Wealth & financial capital	Income and wealth distribution, economic marginalization, accessibility and availability of financial instruments (insurance, credit), fiscal incentives for risk management
Institutions and entitlements	-Informal and formal rules for resource conservation, risk management, regional planning, participation, information dissemination, technology innovation, property rights and risk sharing mechanisms

Sourced from Eakin and Lemos, 2006. Adaptation and the state: Latin America and the challenge of capacity -building under globalization. Global Environmental Change p.10.

Folke, Colding and Berkes (2003) take a broader view identifying four overall elements considered to foster adaptive capacity. These are: **"(i)** learning to live with uncertainty and change by allowing and/or encouraging small scale disturbance events before there is a build up of pressures leading inevitably to some sort of collapse; (ii) supporting and promoting diversity and highlighting the positive connection between diversity and redundancy, both biological and institutional, as a risk diffusion mechanism; (iii) combining different types of knowledge, including Western scientific knowledge and local and/or traditional knowledge across multiple scales and (iv) maintaining opportunities for self organization of social, institutional/organizational and ecological systems in the direction of sustainability" (p.355). These broad characteristics cannot be easily confined to separate determinants, but act as guiding principles for building capacity.

In the IPCC Third Assessment Report (2003), it was assumed more developed countries had greater adaptive capacity than those less developed because of their access to resources such a finances, technology and skills. Extreme weather events such as the 2003 heat wave in Europe and hurricane Katrina in Louisiana 2005 changed this assumption due to the needless loss of life that sustained in both events (Moser & Ekstrom, 2010). These events highlighted that overall adaptive capacity is only as strong as those most vulnerable and that having capacity is not enough, there must be social processes present for it to be mobilized and effective (Moser & Ekstrom, 2010; Nelson et al., 2007). This has further strengthened the 'weakest-link' hypothesis by Yohe and Tol (2002) where any system is limited by it's weakest determinant. Tol and Yohe (2007) develop this hypothesis and also demonstrate that stronger determinants can compensate for weaker ones further reinforcing the interrelationship between determinants.

In summary, this section of the literature review has identified many components and determinants of adaptive capacity. Overall there is a great deal of similarity between the many determinants. However having adaptive capacity is not sufficient it must be mobilized through social processes to be effective (Matthews & Sydneysmith, 2010). The following section further explores the concept of adaptive capacity through a selection of models and applications in a variety of case studies.

2.2.2.2 Models and Applications of Adaptive Capacity

Frameworks are useful for analysing systems and issues so that a fuller understanding of components and their relationship can be attained. Several models have already been developed to explore the relationship of the determinants of adaptive capacity. Three of these will now be discussed in some detail. The first of these

frameworks comes from the exploration of adaptive capacity of Community Based Natural Resource Management (CBNM) by Armitage, (2005) shown in Figure 2.5. The determinants of this framework are listed in Table 2.3. Armitage (2005) expands the understanding of adaptive capacity by dividing determinants as either exogenous or endogenous to a system. This highlights the determinants over which a system has greater or lesser control. An example of an exogenous (operational) determinant would be government policies over which a system has little influence, but which affects the systems adaptive capacity. An example of an endogenous (strategic) determinant would be having access to local knowledge an area the local community have greater control over. Dividing determinants into these categories provides a new perspective for understanding determinants and the power a system has to influence them. This in-turn can help in prioritizing actions for increasing capacity. Separating into these categories also exposes previously hidden influences of power, knowledge, community, and culture and their effect upon adaptive capacity. This model has been applied to Nunavut Canada and Central Sulawesi, Indonesia and later in Fort Resolution, North West Territories, Canada giving insight into how the CBNM can build future capacity.

Figure 2.3: Selected factors influencing adaptive capacity for Community Based Natural Resource Management. Sourced from Armitage 2005, Adaptive capacity and community-based Natural Resource Management. Environmental Management pp.708.

In response to growing recognition of the strong influence institutional factors have on adaptive capacity, Gupta et al., 2010, created the Adaptive Capacity Wheel (Figure 2.6). The definition of institutions upon which this framework is based comes from The Institutions Project of the International Human Dimensions Program. In this context, an institution is a " systems of rules, decision making procedures and programs that give rise to social practices, assign roles to the participants in these practices and guides interactions among the occupants of the relevant roles" (Gupta et al., 2010, p. 460). Institutions are recognized as more than organizations, they include the underlying social ideological values and norms.

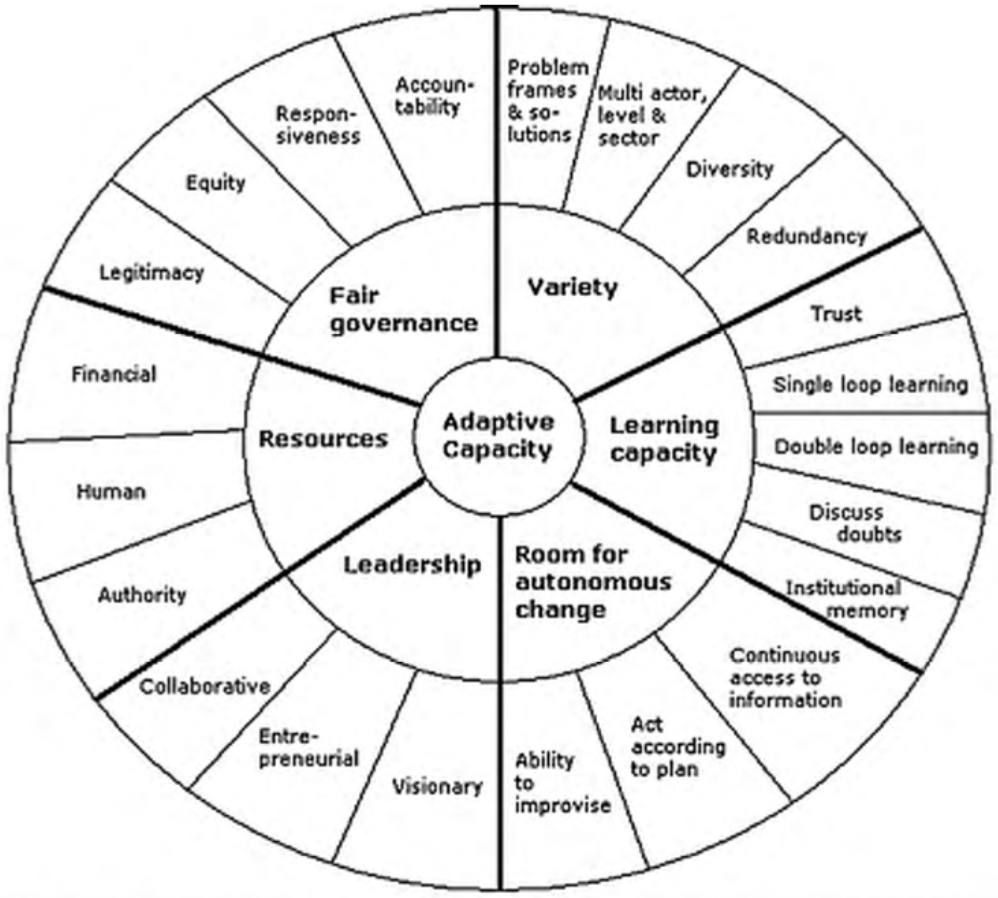


Figure 2.4 Adaptive capacity wheel. Sourced from Gupta et al., 2010. The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. Environmental Science and Policy p.6

Gupta et al., (2010) have concentrated on defining and quantifying the many avenues in which institutions can influence adaptive capacity. They recognize adaptive capacity is fostered by institutions that "allow actors to learn from new insights and experiences in order to flexibly and creatively 'manage' the expected, and the unexpected, while maintaining a degree of identity" (p.461). The framework consists of six dimensions and 22 criteria. Some new determinants for institutions are given along with determinants already noted in section 2.2.2.1. Data are collected on each criterion and the overall capacity of each determinant has a scoring system. Scores are interpreted to indicate if the institution is having a positive or negative effect upon adaptive capacity.

The framework was applied in two Dutch municipalities and provided direction for building adaptive capacity within them.

The final adaptive capacity framework to be explored is by Marshall and Marshall (2007). This model evolves from resilience thinking and examines the social resilience of resource dependent users. Marshall and Marshall (2007) identify the adaptive capacity for resource-users is enhanced when they are "politically, culturally and financially supported and given the opportunity to be flexible, plan, experiment and learn…" (p.37). This is further developed when the innovation and flexibility of the users is supported. The framework highlights the dependent relationship primary resources users have with the ecological environment and how this impacts on their capacity for adaptation. Adaptive capacity is seen as influenced by four key factors: (1) perception of risk associated with change; (ii) perception of the ability to plan, learn and re-organize; (iii) perception of ability to cope, and (iv) level of interest in change (Marshall & Marshall, 2007). Participants are given a series of statements they rate on a four point Likert Scale. The data are analysed and interpreted under the four key factors to give an overall impression of adaptive capacity. The framework was first applied to fishers in North Queensland exploring their capacity to adapt to policy changes. It was then modified to assess the adaptive capacity of Australian cattle-graziers to climate variability, as a precursor to understanding their vulnerability to climate change.

For the most part, these models identify and stress different determinants of adaptive capacity depending on the application. Each further informs and illustrates the complexity of adaptive capacity. The following section offers a critical assessment of the concept, highlighting limitations and knowledge gaps.

2.2.2.3 Adaptive Capacity Through a Critical Lens

Adaptive capacity is a relatively recent and still evolving concept that has few published critiques. Within the vulnerability and resilience scholarship it is frequently cited as a positive attribute but the lack of research and application of the concept have limited it to a desired but vague quality (Engle, 2011; Gallopin, 2006; Smit & Wandel, 2006). While the determinants have become more clearly defined there is still a need to develop measurement and assessment criteria (Engle, 2011; Holland & Smit, 2010). Two main issues constrain the development of an assessment tool. First, adaptive capacity is latent and can only be measured after it has been realised or mobilized (Engle, 2011). Second, adaptive capacity operates simultaneously at diverse scales and there are interactions between and within the various scales and systems, which are poorly understood (Brooks, 2003; Engle, 2011). For this reason adaptive capacity research has generally focused on either the macro national scale, which is too broad for contextualization (Brooks, 2005), or micro scale case studies making generalizations difficult (Armitage, 2005). Given the many institutional and social processes that influence and shaped adaptive capacity it remains heavily context-specific and cannot be generalized between contexts or across scale (Engle, 2011). Researchers note these limitations and continue to explore ways to mange these issues (Brooks, 2005; Engle, 2010)

2.3 Adaptive Capacity Assessment Framework for the Ontario Wine Industry

Given the need for the wine industry to adapt to climate change and the significant effect of adaptive capacity, a review of the wine industry and climate change adaptation literature was completed. The literature review revealed no comprehensive

study or any integrated assessment framework that focused on an empirical evaluation of adaptive capacity of the wine industry. In line with the first objective of this research, and building upon sections 1 and 2 of the literature review, a framework is developed in this section. This framework builds upon the work of Armitage (2005), Gupta et al. (2010), Marshall and Marshall (2007) (see Figure 2.5).

This framework appears similar to the institutional adaptive capacity wheel of Gupta et al., 2010, except that it focuses on the interests of wine industry and categorises determinants as operational or strategic. The framework consists of four circles that identify the elements of adaptive capacity. The inner circle represents adaptive capacity as a whole; the second circle divides adaptive capacity into either operational (exogenous) or strategic (endogenous) determinants; the third circle identifies the specific determinants; and the outer circle shows the indicators used to assess the presence of the determinant within the wine industry.

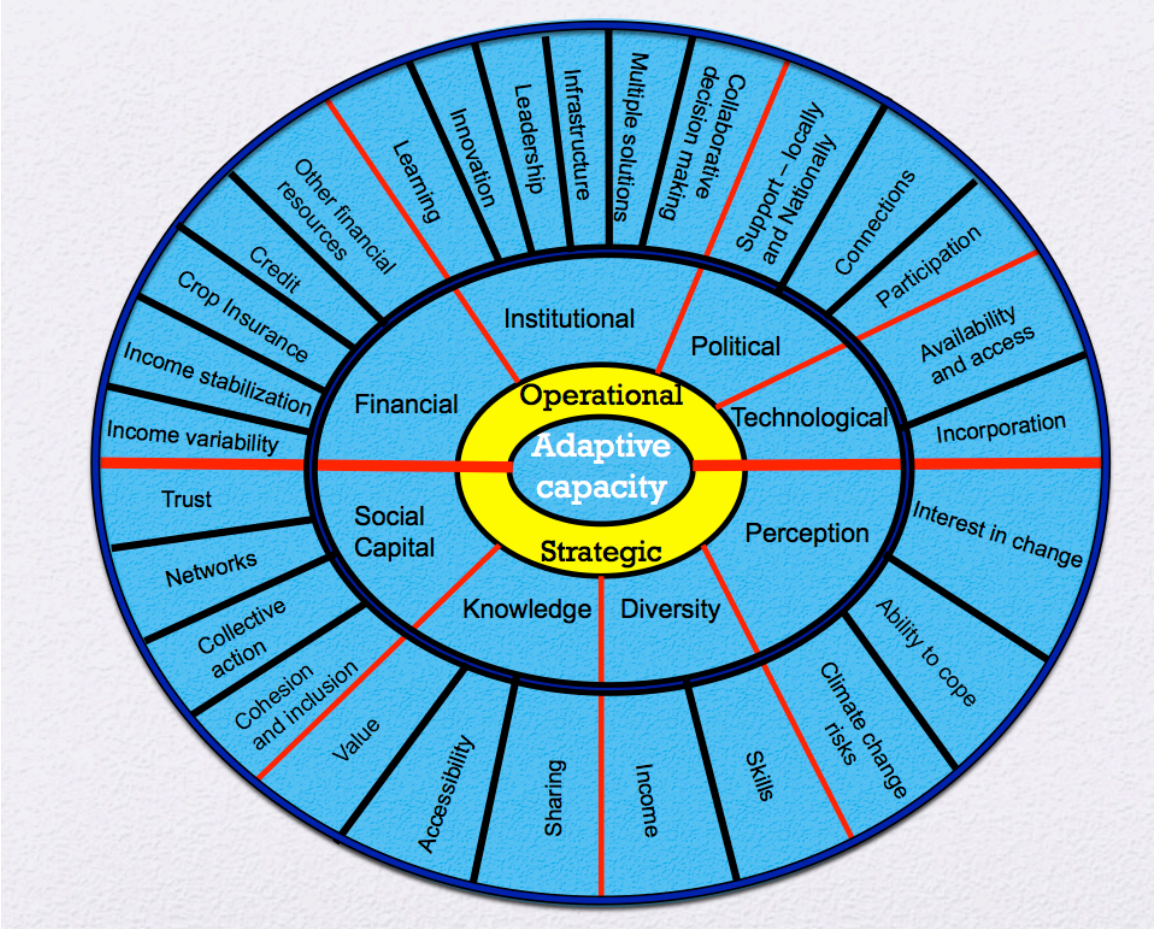


Figure 2.5 Framework for assessing the adaptive capacity of the wine industry.

Each of these eight determinants is defined in Table 2.5. These definitions come from the climate change adaptive capacity literature. The presence of each determinant will be empirically assessed using the associated indicators (refer Table 2.5), which have also come from the wine industry and climate change adaptive capacity literature. These definitions also guide the analysis, interpretation, discussion and recommendations in the following chapters. For example in this framework financial resources are identified as an operational determinant. Access to this resource for the wine industry occurs through crop insurance, credit, income stabilization plans, income variability and other financial resources. It is through these indicators access to this resource will be assessed.

Table 2.5 Determinants and indicators of adaptive capacity for the wine industry

Determinant definition	Indicators
Financial Access and availability to financial resources and variability of income.	Having availability and access to financial resources including instruments such as insurance, credit (Yohe & Tol, 2002; Armitage, 2005; Engle & Lemos, 2007), and financial stabilization programs (Belliveau, Smit & Bradshaw, 2006). The degree of variability of income (Crimp, 2000).
Institutional A system of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices and guide interactions among the occupants of the relevant roles (IDGEC, 1999 in Gupta et al., 2010 p.460).	Collaborative decision making, diversity of solutions, opportunity to learn from past experiences, support for innovation, leadership that is collaborative, visionary and action orientated, utility infrastructure. (Folke, Colding, & Berkes, 2003, Gupta et al., 2010)
Technology The application of tools, methods and technical knowledge.	Availability and access to new technologies (Yohe & Tol, 2002; Johnston, Williamson, Wheaton, Wittrock, Nelson, Hesseln et al., 2008) Incorporation of new technologies into practices (Engle & Lemos 2007; Swanson, Hiley, Venema, Grosshans, 2009; Marshall, 2010)
Political Capacity to influence broader political outcomes (Grootaert Narayan, Nyhan Jones, & Woolcock, 2004)	Political support (Armitage 2005), Modes of participation, (Grootaert et al., 2004; Eakin & Lemos 2006) Political connections as an assessment for getting political action (Wall & Marzall, 2006)
Knowledge The degree to which local-ecological and scientific knowledge are accessible, valued and shared (Armitage, 2005).	Value, accessibility and sharing of local and scientific knowledge (Armitage 2005; Battaglini, Barbeau, Bindi, & Badeck, 2009; Wesche, & Armitage, 2010; Bohensky, Stone-Jovicich, Larson, & Marshall, 2010)
Perception The perceived risk and ability of resources users to cope with and adapt to changes (Marshall, 2010,)	Perception of climate change, risk and ability to cope, (Yohe & Tol, 2002; Adger, & Vincent, 2004; Marshall & Marshall, 2007; Blennow & Pearson, 2008) Level of interest in change (Marshall & Marshall, 2007)
Social capital Networks together with shared norms, values and understanding that facilitate cooperation within or among groups (OECD 2001 in Plummer & Armitage 2010)	Measured as trust between actors, social networks, collective action, social cohesion and inclusion (Pelling & High, 2005; Dudwick, Kuehnast, Nyhan Jones, & Woolcock, 2006; Plummer, & Fitzgibbon, 2007; Gupta et al., 2010)
Diversity The variety of different options available for implementation	Diversity of income (Crimp, 2000; Swanson et al., 2009; Marshall, 2010) Diversity of skills (Belliveau, Smit, & Bradshaw, 2006; Marshall, 2010)

2.5 Summary

This review explored the impacts of climate change on the wine industry and the concepts of adaptation and adaptive capacity. The literature review revealed there are many adaptive strategies within the wine industry in response to the impacts of climate change. Several studies including Battaglini et al., 2009, Belliveau et al., 2006 and Matheson, 2008, have identified important components of adaptive capacity to the industry such as perception of climate change and financial resources. No comprehensive assessment tool for the OWI encompassing the many other determinants identified in the climate change adaptation scholarship was found. A review of the literature surrounding adaptive capacity assessment frameworks was then carried out. In order to expand on this literature a framework has been developed to fill the gaps of assessing the adaptive capacity of the wine industry, as identified by Holland and Smit, 2010.

Chapter 3

Methodology

The need to develop a greater understanding of the adaptive capacity of the wine industry to climate change has been established in Chapters 1 and 2. This Chapter outlines the methodology used to achieve the second research objective – an empirical assessment of the adaptive capacity of the OWI. The empirical assessment builds upon Chapter 2 as it follows the adaptive capacity framework that was developed. The first section of this chapter explains why the case study research method was selected for this study. Yin's (2009), framework for undertaking case study research is then presented and guides the structure this research follows. The stages presented by Yin, (2009), are each addressed with an explanation of how each of these will be followed. These stages include theory development, case study selection, data collection, data analysis and written report. The final section of this chapter addresses the limitations of this study.

3.1 The Case Study Methodology

3.1.1 Rationale for Choosing the Case Study Method

The goal of this research is to assess the adaptive capacity of the OWI to climate change adaptation. The case study methodology has been identified as an appropriate methodology when: (i) researching new theories such as adaptive capacity; (ii) exploring and understanding emerging contemporary phenomena such as adapting to climate change and (iii) where there is an emphasis of the real world context such as the wine

industry adaptation to the impacts of climate change (Baxter & Jack, 2008; Moritz, 2011; Yin, 2009). The case study methodology is widely used in the social sciences (Moritz, 2008; Yin, 2009) and has previously been used in studies of adaptive capacity for climate change (Armitage, 2005; Brooks, 2005; Engle, 2007; Marshall, 2010).

3.1.2 Definition and Features of the Case Study

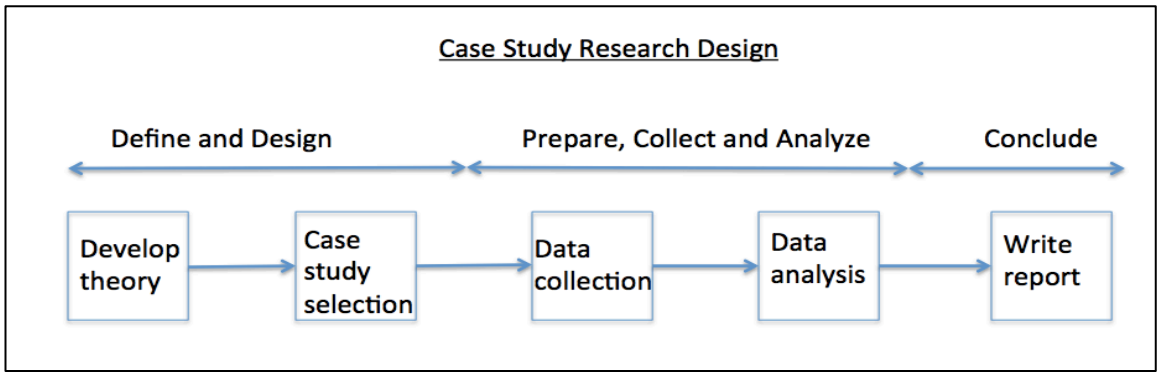
There are many definitions of a case study, Gerring, (2007), highlights eight different case study definitions. Common to these definitions is that a case study is a collection of detailed information about a particular spatially delimited phenomenon observed at a point in time or over a period of time (Gerring, 2007). Defining the case or unit-of-analysis is an essential and challenging first step in case study methodology. It delineates what is being analysed, which in turn influences the research design (Baxter & Jack, 2008). There are three initial components a researcher must define in the selection of the case study methodology which in turn define the case study. These components are the case, the boundaries and the type of study. The case is defined as " a phenomenon of some sort, occurring in a bounded context" (Miles & Huberman, 1994 cited in Baxter & Jack, 2008). It can be many things including an individual, group, program, process or a comparison (Baxter & Jack, 2008). Having defined the case, placing boundaries such as time, activity (Stake, 1995) and place (Creswell, 2003) will ensure the study remains within a manageable scope. Lastly, the type of case study whether explanatory, explorative, descriptive, single or multiple case studies, intrinsic, instrumental or collective, needs to be defined (Baxter & Jack, 2008). In the context of this study, the case is the OWI within the boundary of Ontario. The type of study is explorative in that it

has few preceding frameworks explaining the adaptive capacity of the OWI to climate change.

Case study research has been used since the 1900's but the methodology used today had its beginnings in the 1960's (Baxter & Jack, 2008). It provides a methodology for merging qualitative field study methods with quantitative data analysis methods (Johansson, 2003). Yin is credited for advancing credibility of the approach since the 1960's by "transferring experimental logic into the field of naturalistic inquiry and combined it with qualitative methods" (Johansson, 2003, p.5) creating a methodology that is explicit and inclusive.

Case study research can be undertaken as a multiple case study design or a single study approach. The single case study format is the most appropriate to highlight the uniqueness of a situation (Yin, 2009). Traditionally the single case study approach has dominated case studies of adaptive capacity (Armitage, 2005; Engle, 2011; Gupta et al., 2010; Marshall, 2010) and impacts of climate change on the wine industry (Belliveau, Smit, & Bradshaw, 2006; Diffenbaugh, White, Jones, & Ashfag, 2011; Hadarits, Smit, & Diaz, 2010; Matheson, 2008). Given these traditions and the objectives to focus on the OWI the single case study method has been selected. A depiction of the single case study approach is shown in Figure 3.1 (Yin, 2009). This approach will guide the methods of this research.

Figure 3.1 Single case study research design (from Yin, 2009).



3.2 Research Design for this study

3.2.1 Develop theory

The initial step in the research design (figure 3.1) is the establishment of a theoretical basis for this research. This was achieved by an extensive literature review of the scholarly works of climate change adaptation and adaptive capacity (see chapter 2, section 2.2). From this review an integrated adaptive capacity framework was formed to guide data collection and analysis of adaptive capacity (see Figure 2.5). Having established a framework the wine industry literature informed the development of indicators that identified the concerns and interests of the wine industry.

3.2.2 Case Study Selection

The second step Yin (2009), identifies is the selection of a case, also called the unit of analysis. In this study, the OWI was selected based on four criteria: (i) the interest of the industry to focus on adapting to the impacts and opportunities created by climate change; (ii) on-going adaptation efforts; (iii) unique opportunities that the region offers insights into local adaptive capacity; and (iv) accessibility and manageability of study area.

The Ontario wine industry covers three appellations (see Figure 3.2) and produces 85% of all Canadian wine production; 90% comes from the Niagara appellation (Grape Growers of Ontario, 2011). The industry generates over $3.3 billion annually in revenue for the province, and supports manufacturing, processing, education and tourism (Frank, Rimmerman and Co, 2013). In 2011, there were over 15,000 acres of vineyards and 500 growers producing 53,747 tonnes of grapes for wine (Grape Growers of Ontario, 2011). Vinifera grapes account for 67% of the acreage with more vines being planted each year (Grape Growers of Ontario, 2011). The industry is composed 125 wineries, spread from small family operations to large corporate entities (Vintners Quality Alliance, 2012).

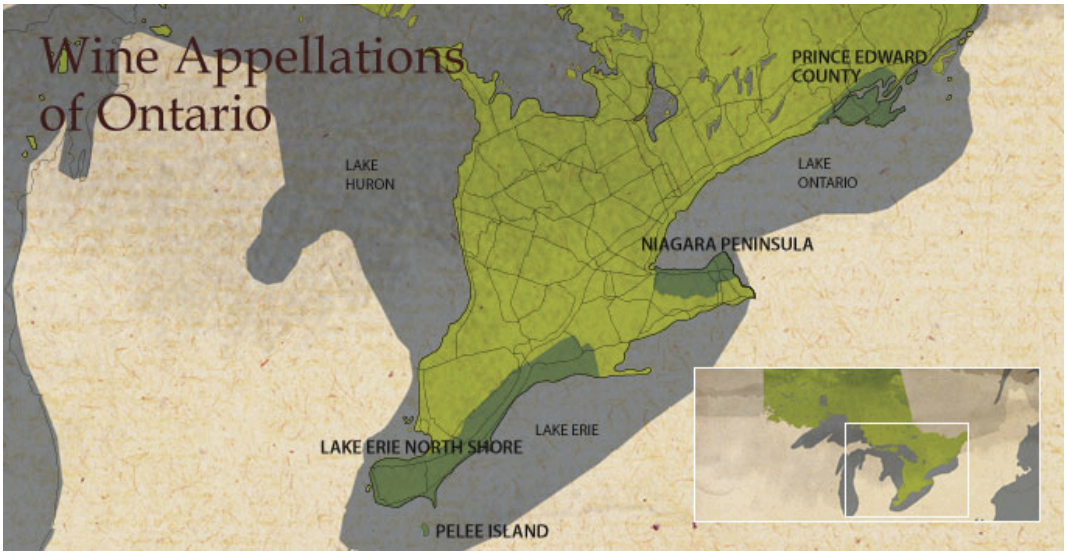


Figure 3.2 Map of the wine appellations in Ontario. Sourced from http://www.vqaontario.com/Appellations

The OWI is supported by four organizations: (i) Grape Growers of Ontario focusing on grower interests; (ii) Wine Council of Ontario assisting wine makers; (iii) Winery and Growers Alliance of Ontario supporting growers and wine maker; and (iv) the Vintner's Quality Assurance Board regulating and maintaining wine quality. The industry continues to grow in Ontario and has seen greater expansion as vinifera grapes

become one of the most valuable fruits in Ontario (Grape Growers of Ontario, 2012). The government supports the expansion of the industry through the Ontario Vineyard Improvement Program, developed to assist wine grape growers to transition to higher demand grape varieties and improve grape quality (Grape Growers of Ontario, 2012). The OWI continues to struggle to gain a greater market share of the wine sold in Ontario. In 2011 38.2% of wines sold in Ontario were from Ontario (Grape Growers of Ontario, 2012). Cheaper imported wines are one of the major marketing challenges facing the industry.

The growing of vinifera grapes to increase the domestic and international competitiveness of the OWI has also increased the vulnerability of the industry to climate change as these varieties have a very narrow growing season compared to the previously grown hybrid varieties. They are particularly susceptible to freeze damage from late spring and early fall frosts and extreme minimum temperature during winter (Shaw, 2005). Although the two great lakes, Lake Ontario and Lake Erie, help to moderate the regional temperature extremes recent climatic changes are creating challenges for the industry. Warmer winter temperatures and increasing freeze thaw cycles in winter are reducing the cold acclimation of the vines and increasing the risk of freeze injury at higher minimum temperatures (Shaw, 2013). A reduction in snow cover that had previously protected vines further increases their vulnerability to freeze injury (Shaw, 2013). At the same time warmer winter temperatures are reducing icewine harvesting period since these are regulated and must occur when temperatures remain between -8^{o}C and -12^{o}C (Shaw, 2013). Requiring the grapes to remain on the wine and exposed for longer periods (Shaw, 2005).

Warmer winters are also allowing the survival of pests such as the Asian ladybeetle. Since 2004 these beetles have become a frequent pests in vineyards decreasing the aromatics of wine by borrowing into grapes bunches and releasing a hormone when crushed with the grapes (Pickering & Lin, 2006). The resulting reduction in wine quality also reduces the wine value.

Changes in precipitation patterns with greater rainfall during the end of the growing season, as experienced in 2011, are also posing challenges to the industry (Vintner Quality Alliance, 2012). Rain at this time predisposes the grape to splitting, increases the chance for fungal disease, it can stop the grapes from ripening and may dilute the juice. All of the outcomes result in reduced fruit quality and value of the wines produced (Cyr, Kusy & Shaw, 2010).

Higher summer temperatures, such those experienced in 2012, are also affecting wine quality through increasing the grape sugar content (brix) and reducing acidity. The higher the brix at harvest the higher the resulting alcohol level following fermentation (Mira de Orduña, 2010). If acidity remains high it can support a higher alcohol content but higher temperature reduce the grape acidity. Both of these impacts reduce the quality and value of the wine produced.

Overall the present climate challenges being faced by the OWI are being well managed and the quality and quantity of wine being produced continues to increase (Grape Growers of Ontario, 2012, Vintners Quality Alliance, 2012). The Canadian and Ontario governments recognize the need for adaptation within agriculture and are developing policies related to long term planning for water shortages, supporting research for drought resistant crops, and monitoring plant pests (Government of Canada, 2010,

Ontario Ministry of Agriculture and Food and Rural, 2011). There are no specific policies in place for the adaptation of the wine industry, but support for research was demonstrated in the recent success of the Ontario Research Fund: Research Excellence fund Round 5. This project brings together researchers from CCOVI, University of Guelph, Vineland Research and Innovation Centre, Ontario Grape and Wine Research Inc. and Niagara College to collectively work with industry partners to adapt to climate change impacts.

3.2.3 Data Collection

The third step identified by Yin, (2009) is data collection. This includes ethics, recruitment, instrument development, and data treatment. Each of these topics will be addressed individually in the following section.

3.2.3.1 Ethics and data collection:

Data collection occurred through a voluntary, anonymous, online questionnaire, approved by Research Ethics Board (REB) at Brock University (Appendix A). No financial incentive or reward system was used to encourage participation. The survey was accessed through Selectsurvey.Net, an online survey tool available at Brock University. All participants were required to agree to a consent form (Appendix B), approved by REB, before proceeding to the questionnaire. The survey software was set so participants had to click 'I agree' on the consent form before accessing the survey. If participants did not agree to the consent they could not proceed. The consent identifies the researchers, project goals, use of information and informs participants they may withdraw at any time without penalty. To ensure each participant answered the questionnaire only once the IP address recognition tool was activated within the software. This option allowed the

identity of the participants to remain anonymous. On the first page of the questionnaire participants had the option to leave an email address, if they wished to receive results from the questionnaire. This information will not be part of the analysis but serves to give feedback directly to participants. All surveys and responses are stored on Selectsurvey.Net which is under password protection and can only be accessed by this researcher.

3.2.3.2 Recruitment

A critique of the case study research method is that of bias both from the participants to make their area look better and from the researcher influencing responses (Yin, 2009). In an attempt to reduce these bias the three main organizations (Grape Growers of Ontario, Wine Council of Ontario, Winery and Grape Alliance of Ontario) representing the wine industry were approached and asked to send an email to members requesting their participants along with the Internet link to the survey. The Vintners Quality Alliance Board members were not approached as their members are present within the other organizations. This ensured there was no direct communication between researcher and participants who remain anonymous allowing them the freedom to express their views. The use of the Likert Scale for responses also reduced the opportunity for any bias from the researcher in the data collection and allows for easier replication of this research.

The emails sent out by the organizations contained a brief explanation of the research, associated goals and identifies the researchers. The initial email was sent out mid -July and replicated in late July, early August and finally in mid- August.

To gain insight from supporting organizations, two appropriate people (director, CEO, research manager) from each organization also received an email about the project. Each person was asked to follow the link and complete the questionnaire. An initial and two reminder emails were sent to these representatives.

3.2.3.3 Instrument Development

The framework directly guided development of the data collection instrument. Each indicator from the framework corresponded to a statement asked in the data collection instrument. Wherever possible, questions that had already been tested by previous scholars were used and sometimes modified for the wine industry. The questionnaire is comprised of three sections: (i) present management strategies for extreme weather events, (ii) adaptive capacity and (iii) perception of climate change. This research deals exclusively with adaptive capacity. As part of a larger project the instrument also posed questions by other researchers to the OWI. Only the adaptive capacity questions will be analysed for this research (see Appendix C for questionnaire). To ensure the questionnaire followed a logical sequence and was clearly understood, it was piloted with four oenology and viticulture researchers, a grape grower, social scientist with some wine industry knowledge and three people with little knowledge of the wine industry. Feedback was then incorporated to create the final questionnaire.

3.2.3.4 Data treatment

The section of the questionnaire that was designed to assess adaptive capacity consisted of a series of statements in which participants indicated their level of agreement with on a Likert Scale (5-strongly agree, 4-agree, 3-neither agree nor disagree, 2-disagree, 1-strongly disagree). Rensis Likert developed the Likert Scale in 1931, as an

attitudinal scale in psychology to indicate the intensity (strongly) and direction (agree, disagree) of a participant's attitude (Croasmun, & Ostrom, 2011). It has frequently been used in the social sciences (Clason & Dormody, 1994; Croasmun & Ostrom, 2011) and has been employed to assess the adaptive capacity of fishers and graziers in Australia (Marshall & Marshall, 2007; Marshall, 2010). The Likert Scale has a rank order where the intervals between values, in theory, cannot be presumed equal but in practice often are (Jamieson, 2004). Hence it is recommended that when data is analysed non-parametric tests be used. In practice parametric test are frequently used but care must be taken with any conclusions drawn (Croasmun & Ostrom, 2011).

Participants can be offered a scale from 3-21 intervals in selecting their best response. Since 1931 when the Likert Scale was first introduced, there has been debate over the number of intervals that should be offered to ensure validity and reliability (Matell & Jacoby, 1971). Researchers wanting to reduce the risk of a bias by forcing a false response in either direction provide a third option (neither agree nor disagree) without diminishing validity or reliability (Croasmun & Ostrom, 2011; Matell & Jacoby, 1971). Pearse (2011) in contrast concluded that 21 intervals gave respondents more choices and was more reliable, even if more time consuming. Given the time restrictions of respondents and the need to maintain validity and reliability, a 5 or 7 interval scale is most frequently used by researchers (Classon & Dormody, 1994; Croasmun & Ostrom, 2011; Dawes, 2008; Jamieson, 2004). A 4-point scale was previously used in adaptive capacity studies by Marshall and Marshall (2007) and Marshall (2010) given the previously stated intention to reduce bias a neutral category was added to the scale creating a 5-point scale for this study.

Another method for reducing the potential for bias in participant responses when using the Likert Scale it offering statements three times; twice in the positive and once in the negative (Marshall & Marshall, 2007). Given the positioning of many statements as yes/no responses the degree of bias was considered minimal, for example a grower either does or does not use crop insurance. At the same time the concern of not frustrating participants with extra questions, it was decided to ask each question once.

The questionnaire responses were downloaded in an Excel spreadsheet from Selectsurvey.Net Each response selected by participants was coded with a numerical number (5-strongly agree, 4-agree, 3-neither agree nor disagree, 2-disagree, 1-strongly disagree). When the data was initially downloaded N = 76: n= 56 growers; n= 18 winemakers; n = 2 organizations. After those who did not indicate any responses were removed N = 42: n= 32 growers, n=8 winemakers and n=2 organization responses. The Excel spreadsheet was organized as growers, wine makers and organizations to allow for analysis between the occupations. This grouping did not influence any later analysis.

3.2.4 Data Analysis

The fourth step put forward by Yin, (2009), is data analysis. Having organized the data into a spreadsheet, a frequency table of all responses to each statement was created. This frequency table was converted to percentages in Microsoft excel. Bar graphs for each of the eight determinants were then created (section 4.1).

Following the analysis of each determinant, a composite analysis to compare the eight determinants against each other. Before this could happen a Cronbach's alpha was required to establish whether there was statistical reliability between the indicators of each determinants (Appendix D). The Cronbach's alpha is widely used in the social

sciences, business and nursing (Bernardi, 1994; Chen, & Krauss, 2004; Connelly, 2011). A Cronbach's alpha is a coefficient of reliability and measures how closely a set of items is related to each other. The alpha coefficient ranges in value from 0-1, the closer the number to 1 the greater the reliability. An alpha of 0.7 is the generally accepted guideline in psychology indicating reliability between items (Bernardi, 2004). The number of items being tested can influence the Cronbach's alpha: the greater the number of indicators (items) the more 'homogenous' a scale can appear, hence for the diversity determinant of only three indicators the alpha appear low but this may well be related to the low number of indicators (Streiner, & Norman, 1989). Several of the determinants alpha scores are between 0.7 - 0.6. Given the low number of indicators for these determinants it was decided the results showed an acceptable statistical reliability supporting a composite analysis of the eight determinants.

As this research is explorative and not statistically driven hypothesis testing, it was decided that a comparison of the mean responses to each determinant should be undertaken. To achieve this, an overall mean for each indicator was calculated in SPSS 20. Using the results, a mean for each determinant was then calculated (Appendix D). The composite analysis was then done using the means of the eight determinants in SPSS 20.

The two dominant groups within the wine industry are wine makers and grape growers. A low response rate from one group of participants may induce a bias when results are analysed. To gain insight if this was occurring in the results a one-way anova was conducted on responses between grower and winemakers in Excel stat, 2012 (Appendix E). The Excel spreadsheet listing grower and winemaker responses was used

for this analysis. The one-way anova takes the responses from growers and analyses it against those of the winemakers, for each indicator, to determine if there is a statistical difference between the responses of the two groups for each determinant.

3.2.5 Report

The last step in Yin's (2008) framework is to provide a final case report that allows the users to bring their findings together. Since this research follows the academic thesis format, the case report step will be presented in the following two chapters: Results and Discussion (Chapter 4) and Conclusions and Recommendations (Chapter 5).

3.3 Study Limitation

This research has limitations that define the physical and conceptual boundaries of this study. The first limitation stems from the funding body for this project. The Ontario Research Fund for Research Excellence Funding Round 5, funds this research, under 'The Impacts of Climate Change on Ontario's Wine Regions' section. This study is a sub-component of a larger project with other researchers covering a broad range of fields. Only the adaptive capacity section of the questionnaire was analysed and discussed in this thesis. It is recognised that many other sectors support the OWI however limitations of time and money preclude their involvement.

The second limitation of this study relates to the concept of adaptive capacity. It is acknowledged that adaptive capacity has been identified in many other disciplines, such as evolutionary biology, anthropology, food security, political ecology and health (Plummer & Armitage, 2010). However, this research is primarily confined to adaptive capacity within the climate change adaptation scholarship.

3.4 Summary

This chapter has explained the rationale for selecting the case study methodology as the most appropriate for this research. It has provided a framework for undertaking a case study. The stages of the framework are each addressed with an explanation of how each of these has been followed along with an acknowledgement of the limitations of this study. The analysis of the data collected from this process will be presented and discussed in the next chapter.

Chapter 4

Assessing the Adaptive Capacity of the OWI

Chapter four presents the results of this research and discusses them in light of the scholarly literature. Responses for analysis consisted of n=32 grape growers, n=8 winemakers and n=2 organizations. The results are presented according to the assessment framework (see Figure 2.5). The assessment framework includes eight determinants and 26 indicators of adaptive capacity. The results for each determinant will be presented and discussed in section 4.1. This provides an opportunity to more fully understand what the participant responses indicate and how this impacts the adaptive capacity of the OWI. Section 4.2 presents the composite analysis of the eight determinants, exposing the interdependency of the determinants and its effect upon adaptive capacity. While the focus of this research is an assessment of the OWI it is important to point out the two dominant groups in the OWI are grape growers and wine makers. A brief review of any differences in responses between these two groups will then follow. The chapter concludes with a summary of the findings.

Section 4.1 The Influence of Resources on Adaptive Capacity in the OWI

4.1.1 Financial Resources

Access and availability to financial resources and stable income support the development of adaptive capacity (Armitage, 2005; Belliveau, Smit & Bradshaw, 2006; Crimp, 2000; Engle and Lemos, 2007; Yohe & Tol, 2002). The results for all indicators of this determinant are illustrated in Figure 4.1. Questions corresponding to the first two

indicators were posed only to growers, as the financial resource of crop insurance for crop failure is only available to them. Results show 45% of the growers rely on crop insurance and less than 40% on credit to help them through what they determine is a 'bad' year. Overall, 40% of the participants indicated they had 'access to financial resources to keep going' while 30% felt they did not. When asked about income variability, over 45% of respondents indicated great monthly variability and 60% experienced great annual variability in income. Stabilization programs were used by 37% of participants.

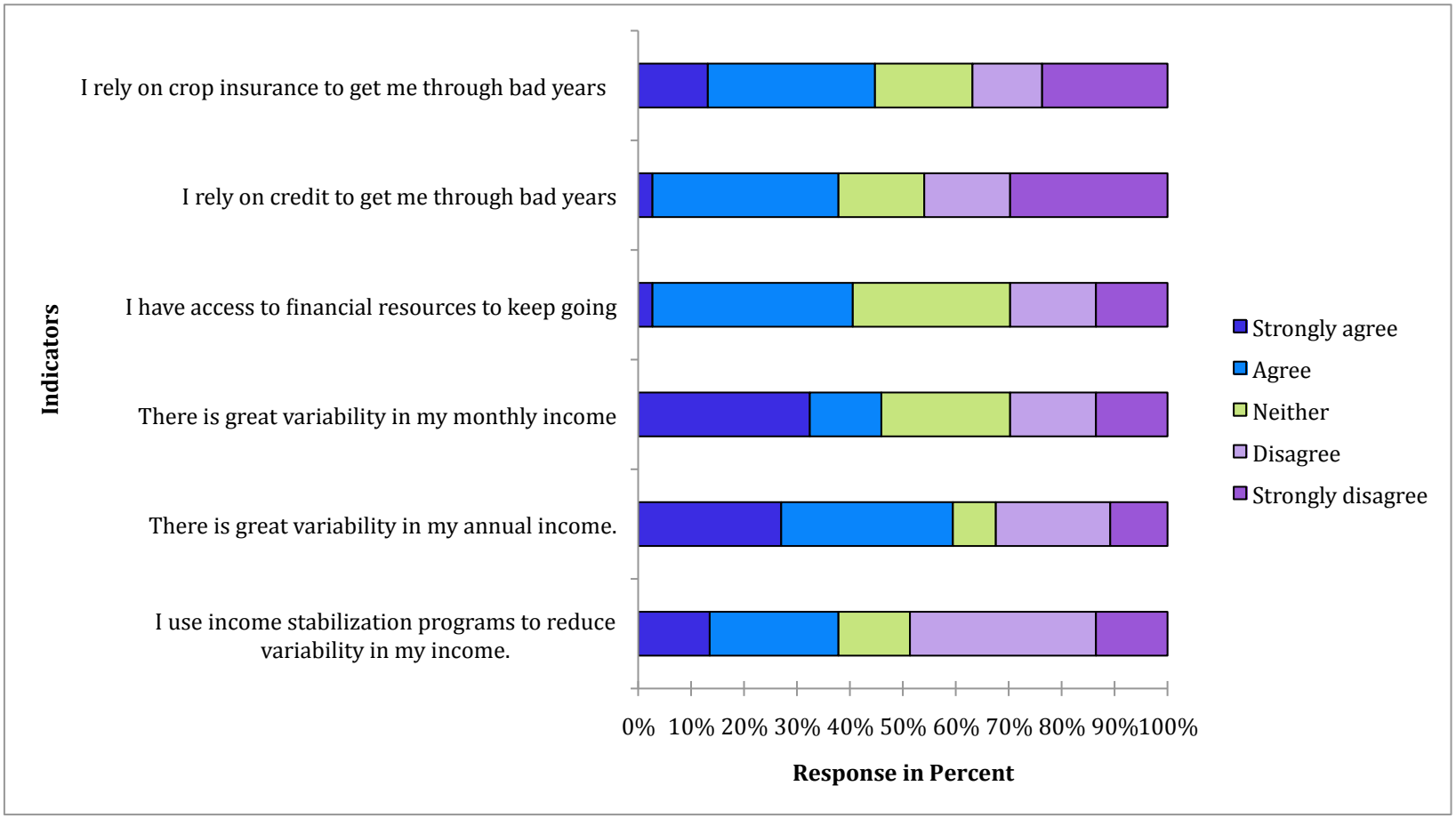


Figure 4.1 Responses to financial indicators of adaptive capacity within the Ontario wine industry (crop insurance and credit n=32, other statements n=42).

The results of the financial determinant provide several interesting insights into how participants of the OWI understand their access and availability to financial resources. Adaptive measures require both funding and the support of those who control money to be directed toward them. Yohe and Tol (2002) demonstrate how a lack of access and direction of financial resources reduces adaptive capacity by limiting the development and implementation of adaptive strategies, increasing the physical and social vulnerability of those already at risk. Financial resources occur in many forms. Those pertinent to the wine industry include crop insurance, credit, and stabilization programs. These resources reduce the financial hardship on growers from external stimuli such as extreme weather events (Agricorp, 2012; Grape Growers of Ontario, 2012). In Ontario, all grape growers have access to crop insurance and income stabilization programs, subsidized up to 60% by the federal and provincial government (Agricorp, 2012). Results from this study and the OWI literature (Grape Growers of Ontario, 2012) show a limited uptake of these resources by OWI growers. This limited uptake of crop insurance and stabilization programs against low-probability high-loss events are experienced internationally, even when subsidized (Adger et al., 2007 p.734). There is a lack of academic or industry literature to explain why growers do not purchase crop insurance. White, (n.d) has suggested it could be due to a misconception by farmers that crop insurance is an investment tool not a risk management tool. Boyd, Pai, Qiao, & Ke, (2011) suggest farmers must be sufficiently risk adverse and that losses must be of sufficient size for farmers to be interested in purchasing crop insurance, even when subsidized. The decision to purchase insurance is understood as a cost–benefit decision for the buyer in other words does the risk of loss (cost) from an event outweigh the cost

of paying for insurance? The higher the perceived risk of loss the greater chance insurance will be purchased (Menny, Osberghaus, Pohl, & Werner, 2011; Sherrick, Barry, Ellinger, & Schnitkey, 2004). Presently in Ontario, grower's perception of climatic risk could be reduced by the overall favourable grape growing conditions being experienced (Qian, Gamda, Zhang, & De Jong, 2012) and the absence of a recent major crop loss event. In 2005, when 50% of the grape crop was lost, 92% of growers with crop insurance made a claim (Grape Growers of Ontario, 2012), suggesting when events do occur crop insurance is mobilized. Returning to the results, 20% of growers choose the option 'neither agree nor disagree' as a response to using crop insurance. In this study this response is considered as a refusal to answer the question.

Access and availability of financial resources for the agricultural sector have frequently been assessed through crop insurance and credit data (Brown & Ward, 2011). Financial resources occur in many other forms such as savings, investments, property, bonds, products and so on. These types of assets can be liquidated to help in times of hardship. In an attempt to gain insight into these resources, and be respectful of participant's personal affairs, all participants were asked if they felt they had access to financial resources to keep going. The statement is general but is based on the understanding by Nelson et al., (2007) and Engle, (2011), that such resources may be latent until they need to be mobilized during or after an event. Asking participants this question allows them to candidly indicate if they feel they have such resources; 40% felt they did. This indicates there may be financial resources other than crop insurance, credit and stabilization programs, which may increase adaptive capacity when called upon.

A variable income has been identified as reducing adaptive capacity by keeping individuals within a coping cycle and not an adaptive cycle (Adger et al., 2007). When income varies individuals save to cope in periods of low income, not investing in adaptive strategies such as new technologies (Crimp, 2000; Nelson, Kokic, Elliston, & King, 2005). When incomes are stable individuals can plan for future investments (Nelson et al., 2005). While participants identify a variable income, the use of income stabilization plans, as a risk management tool, is less than 40%. In Ontario, stabilization programs cover income reduction from reduced productivity to market fluctuations and are subsidized up to 60% by the federal and provincial government (Agricorp, 2012). There appears to be a void in the literature informing the reduced use of this risk management tool.

Overall there is access to financial resources in the form of subsidized crop insurance and stabilization programs for the OWI. Presently there is limited implementation of these risk management tools. An increase in purchasing of crop insurance and stabilization programs will assist the industry to access financial resources in the short term enhancing its present adaptive capacity to extreme weather events.

4.1.2 Institutions

Institutions are defined as the 'system of rules, decision-making procedures, and programs that give rise to social practices; assign roles to the participants in these practices and guide interactions among the occupants of the relevant roles' (IDGEC, 1999 in Gupta et al., 2010 p.460). They can foster adaptive capacity by creating an environment, which supports actors in both learning from past experiences and developing new insights, enabling them to have flexibility and creativity in managing expected and unexpected situations (Gupta et al., 2010). The results for this determinant are illustrated in Figure 4.2. Results show 43% of participants felt the OWI involved multiple stakeholders in solving complex problems such as climate change. When questioned if there were many policy options to assist in managing climate change and extreme weather events, 44% of respondents indicated this was not available. Almost half of participants felt changes to improve present practices and the implementation of new techniques were encouraged by the institutions. Over 55% of respondents agreed there was room in the OWI for leaders who promoted long term vision, action, collaboration, and entrepreneurship. Another important role of institutions is in supporting and developing infrastructure, especially access to water infrastructure to irrigate vines to reduce damage from extreme temperature events. Half of participants indicated they do not have access to water infrastructure for irrigation.

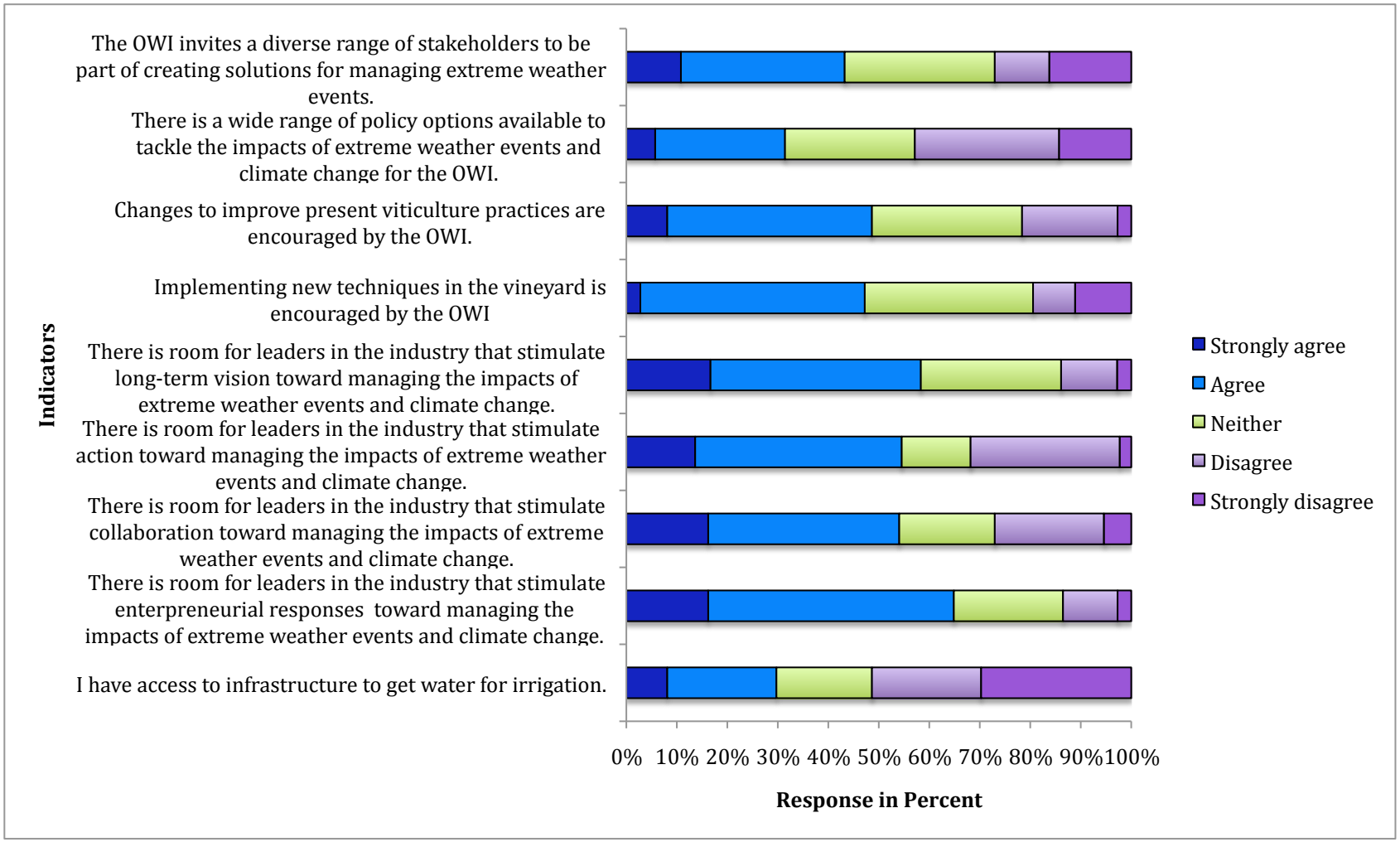


Figure 4.2 Responses to institutional indicators of adaptive capacity within the Ontario wine industry.

Institutions are more than organizations; they encompass the values and norms of a social group (Gupta et al., 2010). To activate and direct adaptive capacity appropriately institutional structure must be in place (Nelson et al., 2007). Following is a discussion of the results of the institutional determinant for adaptive capacity within the OWI.

Climate change has been labelled a 'wicked' problem in part because the solutions to it depend upon how the problem is framed and there are multiple ways of framing it, thus giving multiple solutions (Rittle & Webber, 1973). Solutions therefore benefit from the input of a variety of stakeholders (Folke et al., 2007; Levin, Cashore, Bernstein, & Auld, 2007). Participants in this study report there is a limited range of stakeholders engaged in finding solutions to climate change for the OWI. An example where this engagement is occurring is the research based at Cool Climate Oenology and Viticulture Institute, Brock University where 19 researchers and 25 industry and non-industry partners across Ontario are working together in developing adaptive strategies to climate change impacts for the OWI.

Complex problem such as climate change require multiple policy options for developing and implementing an array of adaptive strategies (Gupta et al., 2010). A range of policy options reduces the chance of getting locked into development that may reduce future adaptations (Nooteboom, 2006). When surveyed on the range of policies available to assist the OWI for climate change adaptation respondents signalled these were limited at present.

Another characteristic of institutions that enables adaptive capacity is learning; encouraging and supporting actors to learn from past experiences to improve present and future practices (Armitage, Marschke, & Plummer, 2008). The majority of participants in

this study indicated the OWI fosters these attributes through encouraging new and improved practices. In doing so the industry displays its support for learning from past mistakes and supporting active change.

The ability to build autonomous capacity is another attribute institutions can foster to build adaptive capacity. This requires institutions to allow stakeholders to seize opportunities and develop their own self-help strategies to events (Pelling, & High, 2005). In times of disaster when victims must undertake their own immediate relief efforts, their ability to improvise has been demonstrated as critically important (Tierney, Bevc, & Kuligowski, 2006). Institutions encourage this quality when they support experimentation when responding to everyday contingencies and opportunities. It reflects the openness of the industry for new and innovative practices that stakeholders may choose to independently implement. Over two thirds of those who responded to this question identified autonomous capacity was present within the OWI. This implies there is a level of flexibility within the industry for stakeholders to experiment and be innovative with new ideas, which may provide an opportunity to develop new adaptive strategies.

Leadership that drives, directs and motivates change is believed to enhance the ability to respond to complex problems such as climate change in institutions (Gupta et al., 2010). Specifically encouraging the emergence of leaders with long-term vision, action, collaboration, and entrepreneurial qualities provides the opportunity to reshape and transform institutions in times of change (Gupta et al., 2010). These qualities are seen as being supported within OWI by the majority participants in this study. This result suggests there is support within the industry for leaders of change to develop and direct

the industry. At present this may be a latent quality that when required may be mobilized; however its presence strengthens the adaptive capacity of the industry.

The institutional and organizational structures that support the OWI include the municipal, provincial and federal governments. These levels of government influence the availability, access, and up-keep of infrastructure, which is of great importance to primary resources users. Of specific interest to the international wine industry is the access to water infrastructure for irrigation to reduce the impacts of droughts, extreme temperatures and frost. A lack of access to water infrastructure has become a limiting factor for wine production in Australia, Spain and California (Alonso & O'Neill, 2011). At the present time Shaw, (personal correspondence 2012) states a lack of water access is not a significant factor limiting wine production in Ontario. As the climate changes with a predicted increase in summer temperatures and more freeze thaw events (Bélanger, Rochette, Castonguay, Bootsma, Mongrain, & Ryan, 2002), it is not unreasonable to expect that there will be an increase in demand by growers for access to water infrastructure for irrigation. In this study 50% of participants indicated they did not have access to water infrastructure for irrigation. While this is perhaps not an immediate limitation for the OWI, it is an issue that requires monitoring and strategic planning for future climate scenarios and as a consideration when expanding the industry into new areas.

Participants have identified the indicators of the institutional determinant of adaptive capacity are present within the OWI. The level of some indicators such as learning capacity, autonomous capacity and encouraging leadership qualities appear to be

slighter greater than the range of policy options and access to water infrastructure. Increasing the level of each indicator would increase the adaptive capacity of the OWI.

4.1.3 Political

The ability to influence the political environment supports the development of adaptive capacity by empowering stakeholders and developing a supportive political environment (Grootaert et al., 2004; Johnston et al., 2008; Smit, 2001). The results for the four indicators of this determinant are illustrated in Figure 4.3. Participants indicated there is greater political support for the OWI provincially than nationally. With respect to political connections, the responses were evenly divided between those who agreed there were political connections, those who disagreed and those who did not answer. When indicating their own personal political involvement just under 70% felt they were politically active when the opportunity arose.

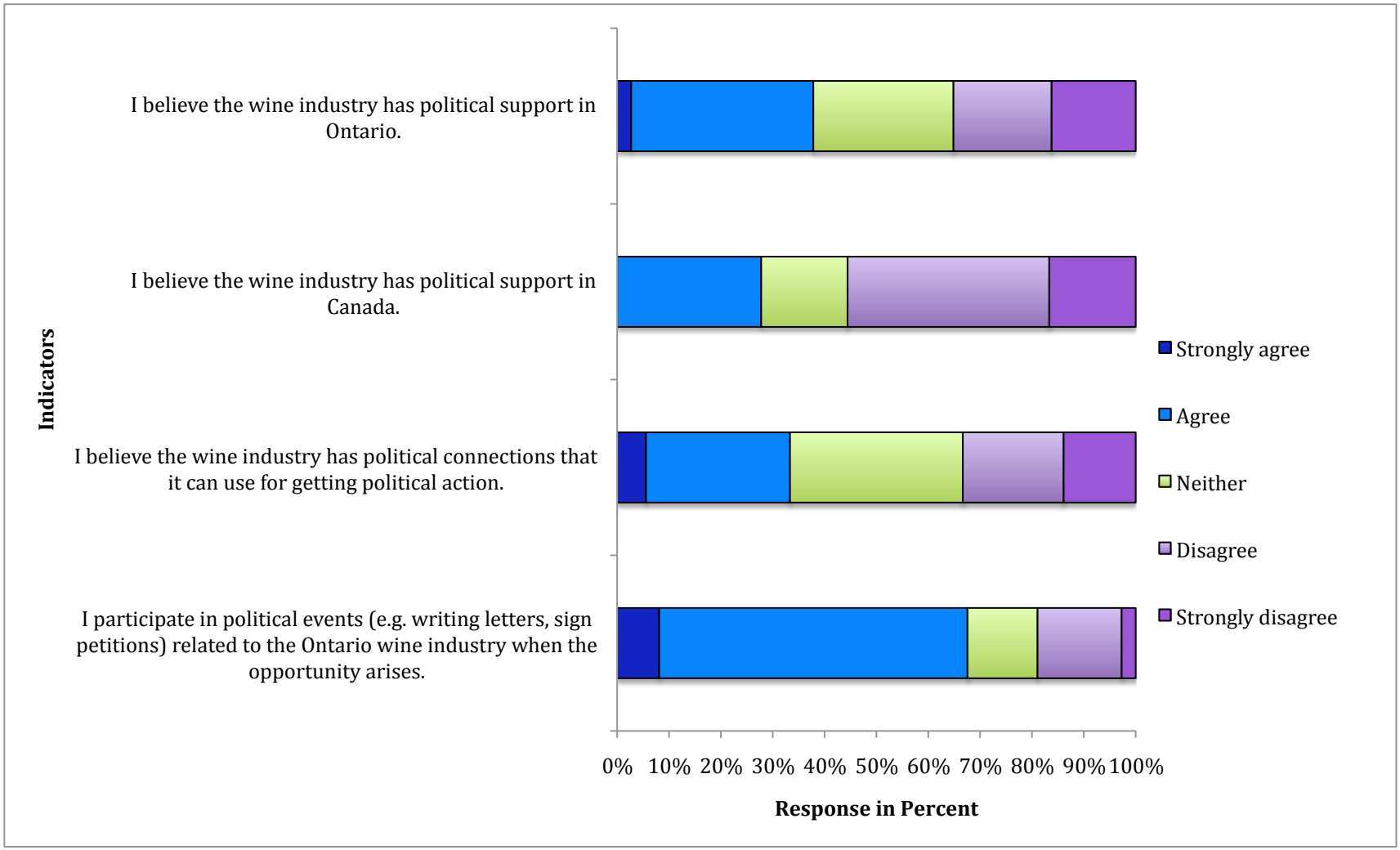


Figure 4.3 Responses to political indicators of adaptive capacity within the Ontario wine industry.

The following discussion of the results associated with the political determinant will enable a greater understanding of its influence on the adaptive capacity of the OWI. It is well recognised that policies and regulations can constrain or enhance adaptive capacity (Eriksen, 2004; Johnston et al., 2008; Smit et al., 2001). Political connections and support are avenues used for influencing policies, regulations and the political will of those with power (Grootaert et al., 2004). The participants in this study indicate there is a level of provincial and national political support for the industry. A brief review of the Grape Growers of Ontario, Wine Council of Ontario, Vintners Quality Alliance and Winery and Growers Alliance of Ontario websites shows these OWI representatives are communicating with the provincial and federal government on a regular basis to advocate for the needs of the industry. The websites also illustrate some of the political connections between the OWI and other political bodies.

Political participation is a channel for individuals to feel empowered and that they have a measure of control over political processes affecting their everyday lives (Grootaert et al., 2004). Ways in which people can exert this control includes letter writing to political representatives, signing petitions, participation in public meetings and elections. Respondents in this study consider themselves to be politically active, indicating they feel a sense of power to influence political decisions. Questions related to attending AGM and voting were removed from the questionnaire as requested by the organizations, preventing the collection of empirical evidence to support this claim.

Overall the political indicator of adaptive capacity signals that the industry has a level of political support and connections that can be used for getting provincial and federal political action. Members within the industry feel a level of empowerment to

influence political decisions affecting the industry and actively use this power when opportunities present themselves. All of these actions serve to enhance adaptive capacity.

4.1.4 Technology

Access and incorporation of new technologies into present practices facilitate adaptive capacity for climate change in adaptation (Engle, 2011; Johnston et al., 2008; Marshall, 2010; Yohe & Tol, 2002,). An example of a new technology for the OWI is the use of early warning weather systems. This alerts growers when cold temperatures may cause damage to vines and buds so devices such as wind machines can be activated reducing damage to the vines. The results for the two indicators of this determinant are illustrated in Figure 4.4. Results show 42% of participants disagree with the statement and perceive they have access to new technologies that allow them to implement changes in their present practices in anticipation of climate change. Conversely 36% of participants agree with the statement and feel they do not have adequate access. When new technology is available in the form of weather warning systems 58% of respondents have incorporated this technology into their practice.

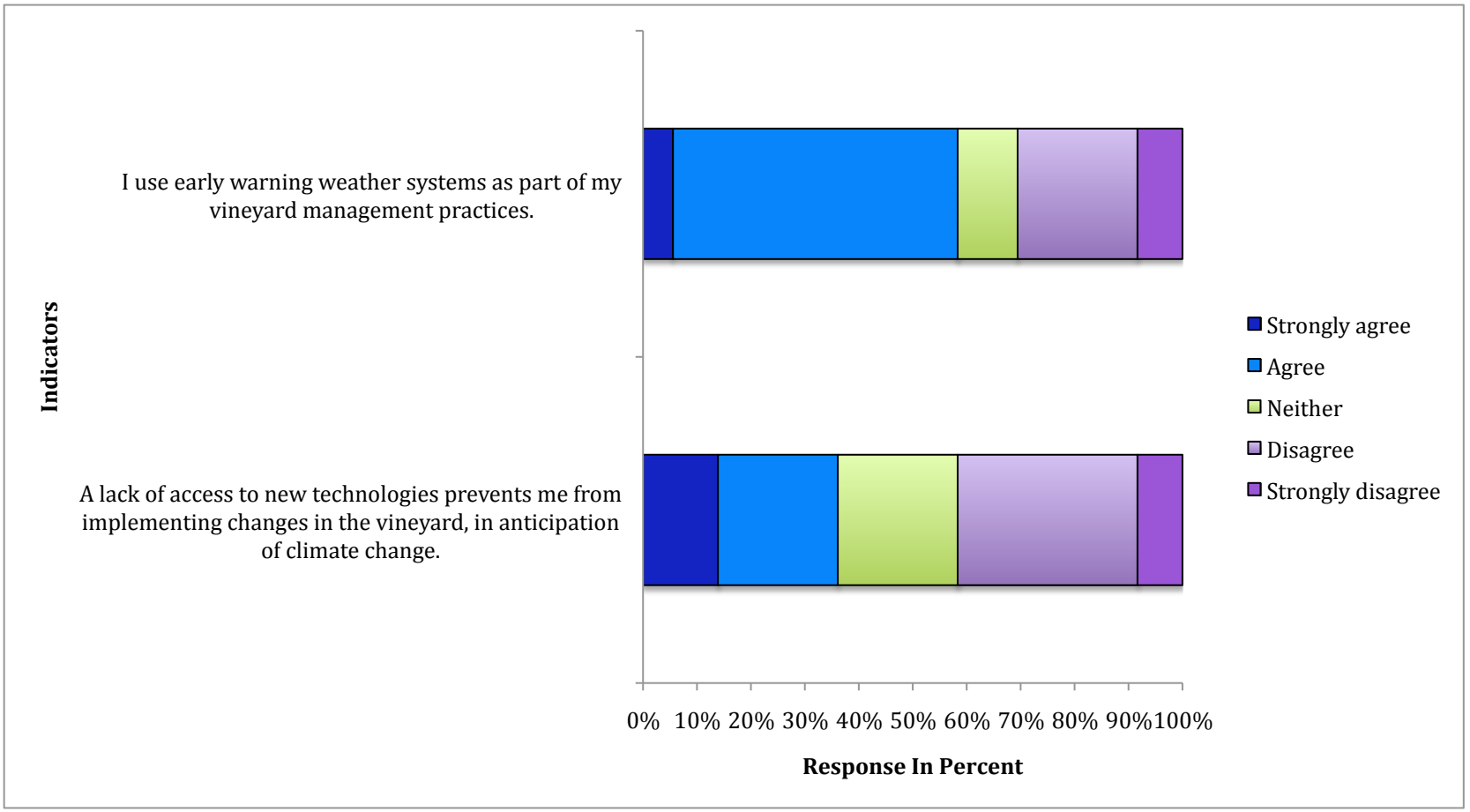


Figure 4.4 Responses to technology indicators of adaptive capacity within the Ontario wine industry.

The results associated with the technology determinant require further discussion, as there is incongruence in participant responses. The early warning system is a new technology alerting growers and winemakers when low temperatures may impact on the health and viability of the vines. This allows the implementation of strategies, such as turning on wind machines, reducing the potential for vine injury. In Ontario the use of wind machines has grown rapidly in the past 5 years with over 500 wind machines now operating within the OWI (The Grower, 2010; Fraser, 2012). Responses from participants indicated 40% felt they had access to new technologies, and yet almost 60% indicated they were incorporating the use of an early weather warning system. This response indicates more participants are actually using new technologies rather than perceiving that they have access to them.

Adaptive capacity is a process that can be influenced by access to new technologies and individual decisions to incorporate these technologies (Engle, 2011; Johnston et al., 2008; Marshall 2010). Overall there is a level of access to new technologies, however it seems there is a misperception of what constitutes new technologies.

4.1.5 Perception

Perceiving the risks and benefits associated with climate change, partially drive the process of adaptation and influence adaptive capacity (Grothmann & Pratt, 2003). Results for the determinant of perception are shown in Figure 4.5. Participants in this study perceive climate change will have both positive and negative impacts for the OWI. There is a greater perception of the positive impacts than the negative, by respondents. The majority of participants felt they would survive future extreme weather events, but

new skills outside the industry may be required to manage these impacts; 73% of participants were interested in this option. When asked specifically of their interest in learning ‘how to better prepare for extreme weather events’ and ‘climate change’, there was a high level of interest by over 90% of participants.

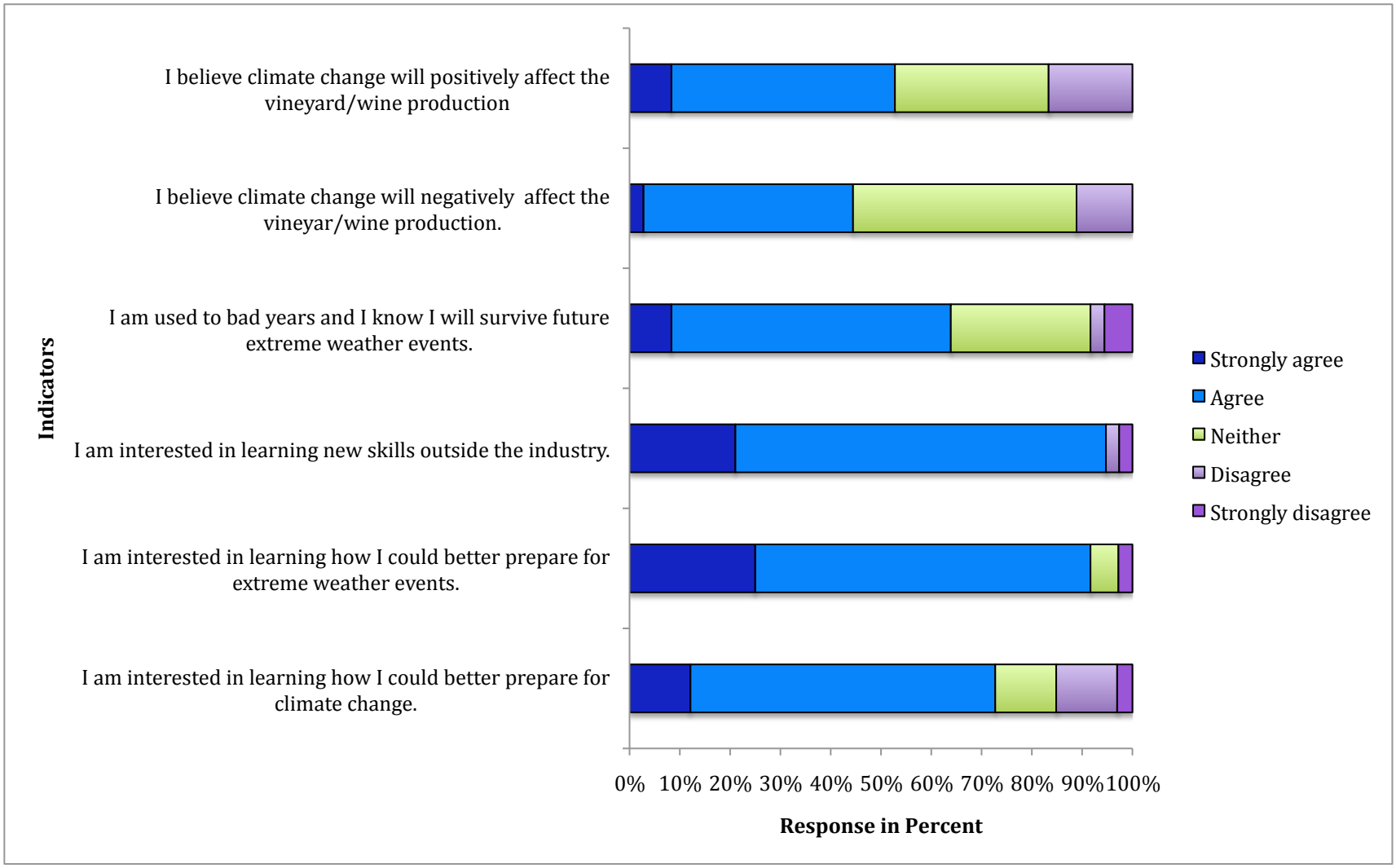


Figure 4. 5 Responses to perception indicators of adaptive capacity within the Ontario wine industry.

Perception of climate change influences the adoption of new adaptive strategies affecting adaptive capacity. Those who do not perceive the risks or opportunities associated with climate change are less inclined to adopt new adaptive practices, increasing their susceptibility to climate change impacts (Grothmann & Pratt, 2003). The results from this study show very few participants did not perceive climate change would have either positive or negative impacts for the industry.

Adaptation to climate change and extreme weather events may require stakeholders to learn and develop new skills within and outside the industry. Results from this research indicate participants have a great interest in learning new skills to better prepare for these events. Having a perception and an interest in developing new skills to manage new challenges, demonstrate a desire for learning enhancing adaptive capacity (Folke, Colding, & Berkes, 2003; Marshall, 2010). In this study more people were interested in learning how to manage these events than perceived these events would affect the industry.

The perceived proximity of individuals to their coping threshold, identified as their ability to survive future events, can affect adaptive capacity (Marshall, & Marshall, 2007). Marshall, (2010) found primary producers who did not perceive they were close to their coping threshold were more likely to be strategic in their practice and adopt innovative technology enhancing their adaptive capacity. Results from this study indicate the majority of participants did not perceive they were close to their coping threshold implying there is the potential to build adaptive capacity within the industry through strategic planning and innovative technology. Marshall, (2010) cautions that such perceptions can also work against adaptive capacity as stakeholders may not fully

perceive how future climate will challenge their skills and may not integrate new technologies believing they can cope. Given the contradictory consequences this perception can have on adaptive capacity, a more in-depth understanding of the perception held is required.

Overall participants indicate there is a perception of the risks and opportunities associated with extreme weather events and climate change, coupled with this is an even greater interest in learning how to adapt to these. The individuals in this study do not perceive themselves to be at their coping threshold suggesting there is room in the industry for strategic planning and the integration of new technologies, enhancing adaptive capacity.

4.1.6 Diversity

Diversity enhances adaptive capacity by providing greater opportunities for developing creative and novel solutions to complex problem like climate change (Folke, Colding, & Berkes, 2003). While diversity can be found as a component in many of the determinants, the climate change adaptation literature draws particular attention to diversity of income and skills for increasing adaptive capacity (Crimp, 2000; Marshall, 2010). The results of the statements given to participants in these areas are shown in Figure 4.6. Income other than grapes and wine were reported by 64% of participants. Incomes sources outside the OWI were reported by 42% of individuals. To assess diversity of skills participants were asked if they felt they had career options available to them if they choose to leave the wine industry; over 77% felt they did.

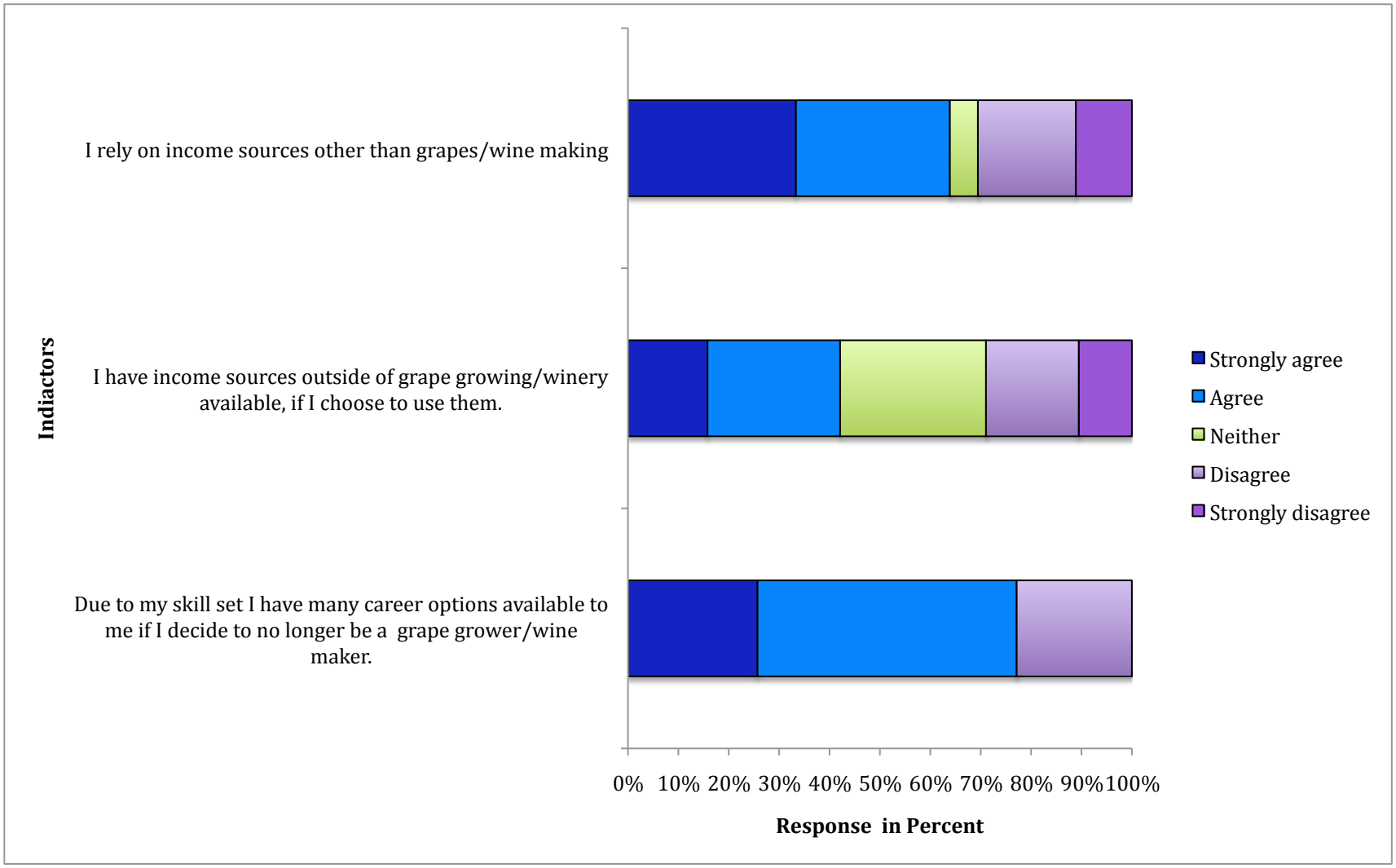


Figure 4.6 Responses to diversity indicators of adaptive capacity within the Ontario wine industry.

Primary resource users, such as grape growers and wine makers, have a high financial dependency on natural resources, and consequently are hypothesised to have greater financial susceptibility to climate variability (Eakin, & Bojorquez-Tapia, 2008). Income and skill diversification can dilute this dependency and increase the ability to adapt to change (Marshall, & Marshall, 2007; Nelson et al., 2010). Marshall, Fenton, Marshall and Sutton, (2007) explore the relationship between resource dependency and social resilience, identifying users with transferrable skills and multiple income sources as having greater adaptive capacity for change. Bailey & Pomeroy, (1996) demonstrated people with broader income sources and skills had more options and were able to adapt to fluctuations in the marine environment, in a case study of Southeast Asian fishing households. Results from this study indicate diversification in both income sources and transferrable skills are already present within the OWI.

4.1.7 Knowledge

A willingness to integrate various knowledge sources supports the learning process and builds adaptive capacity (Armitage & Plummer, 2010). Results for this determinant are shown in Figure 4.7. Respondents indicated that local knowledge is accessible to 80% of participants and scientific knowledge to 70%. The majority of participants indicate local and scientific knowledge is shared within and between the different stakeholder groups in the industry. Both knowledge types are valued by most of the participants.

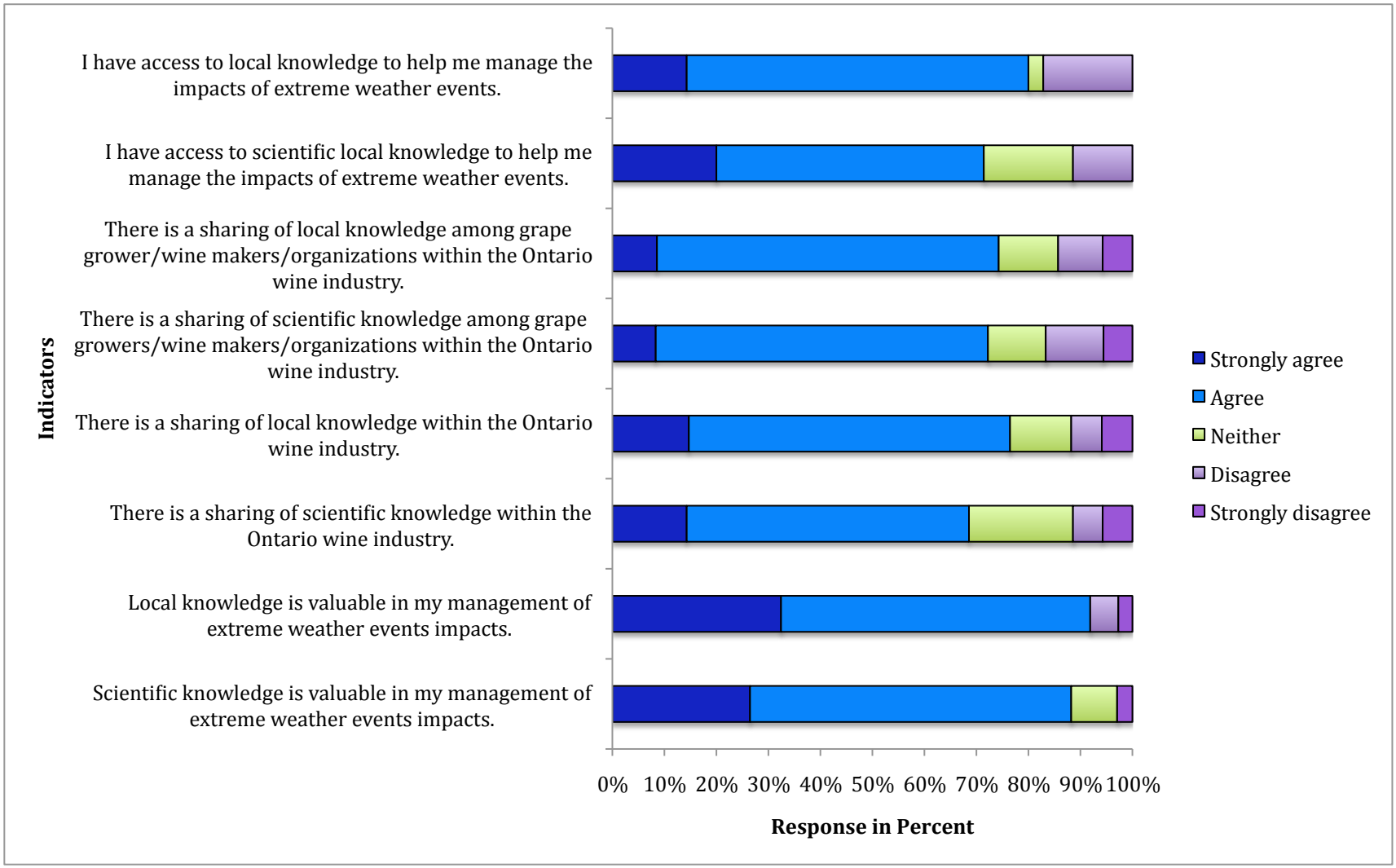


Figure 4.7 Responses to knowledge indicators of adaptive capacity within the Ontario wine industry.

The friction between the value of local and scientific knowledge is well documented (Argawal, 1995; Beckford, & Barjker, 2007; Gadgil, Olsson, Berkes, & Folke, 2003). Local knowledge is discredited for its lack of objectiveness and imbedded beliefs systems (Briggs, 2005), yet it provides information on the local scale for place specific adaptations (Lebel, Anderies, Campbell, Folke, & Hatfield-Dodds, 2006). Scientific knowledge is criticised for being too objective causing the neglect of social, cultural, economic and political influences (Maddrell, 2009), while providing the technology required for many adaptations. Valuing, sharing and having access to both types of knowledge support the development of adaptive capacity (Armitage 2005; Folke, Colding, & Berkes, 2003) and adaptive strategies (Adger et al., 2007). Reed, Dougill, and Taylor, (2007) demonstrate how utilizing both forms of knowledge provided a range of place specific adaptations for Kalahari range managers increasing their capacity to adapt to climate change. Within the OWI participants indicate local and scientific knowledge are accessible, valued and shared. An example of how these knowledge types are presently assisting the OWI in adapting to extreme weather events is the increasing use of wind machines in vineyards susceptible to late spring and early fall frosts. Scientific knowledge developed the wind machine while local knowledge assists in its location and development of best management practices.

Overall, the results indicate scientific knowledge is less accessible, shared and valued than local knowledge. Understanding that scientific knowledge is a key component in adaptation the industry would benefit from facilitating greater access and sharing of scientific knowledge. A continuation and expansion of adaptive strategies,

which evolve from a combination of both knowledge types, will continue to build adaptive capacity for the OWI.

4.1.8 Social capital

Social capital is defined as "networks together with shared norms, values and understandings that facilitate co-operation within or among groups" (Organization for Economic Cooperation and Development, 2001, p.41). It builds adaptive capacity within a group through the following attributes: cooperation, networks, trust, cohesion and inclusion (Adger, 2003; Adger et al., 2007; Dudwick et al., 2006; Pelling, & High, 2005). Results for the social capital determinant are shown in Figure 4.8. Over 90% of participants believed those within the industry are willing to help others while 80% felt this was currently happening. Almost 80% of respondents indicated they talk to others, with the same occupation within the industry on a weekly basis. If they suffered a harvest failure, 44% of participants believed there were people within the industry who would assist them. The majority of respondents agreed 'people within the industry could be trusted'. A strong sense of closeness within the industry was present for 38% of participants and 54% felt they were not excluded from events within the industry.

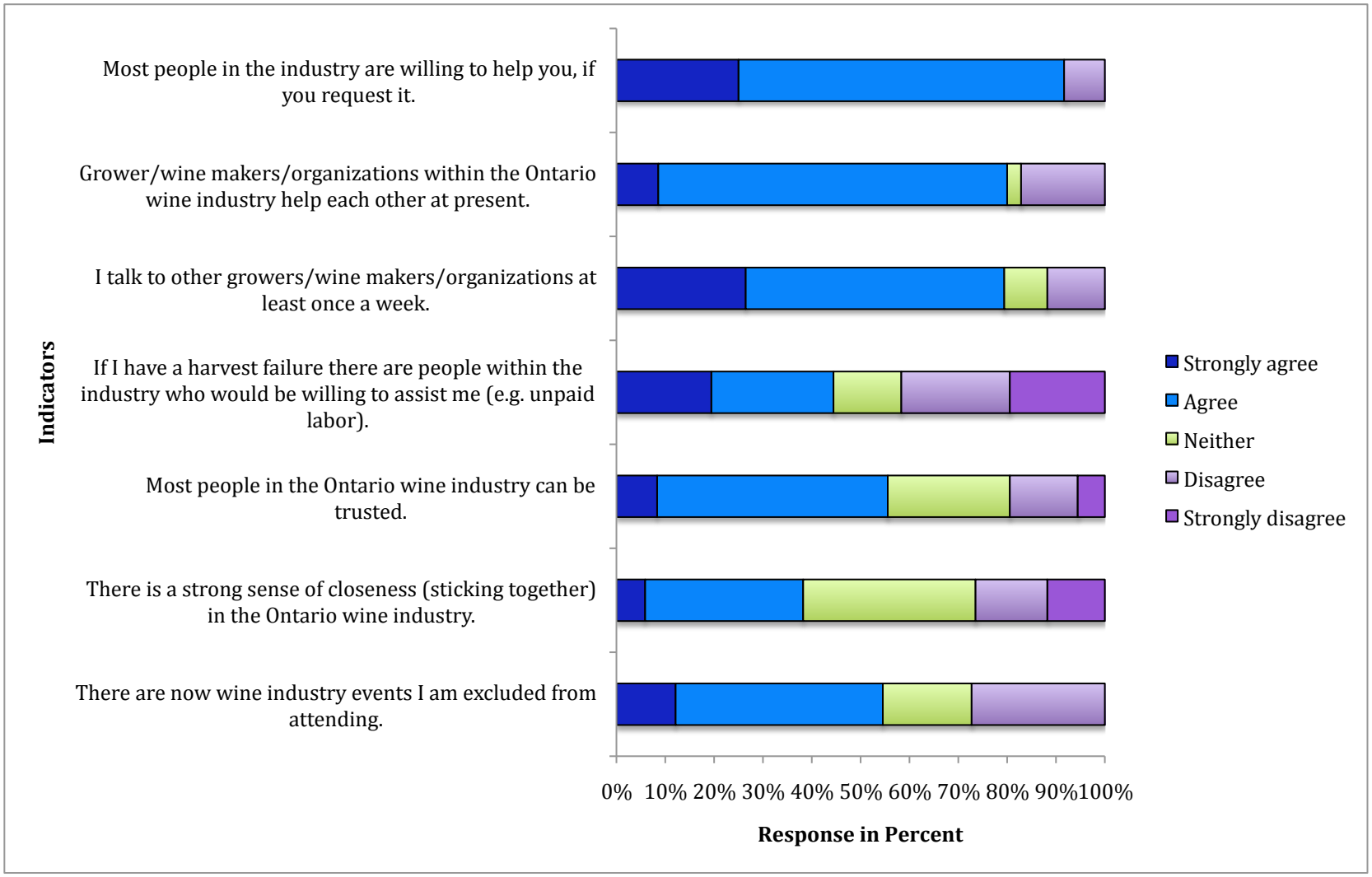


Figure 4.8 Responses to perception indicators of adaptive capacity within the Ontario wine industry.

Social capital develops adaptive capacity by providing access to information and resources that individuals and groups might otherwise not have and by supporting collective action (Pelling & High, 2005). Collective action requires networks and flows of information to assist with decision-making achieved through cooperation, social networks, trust, cohesion and inclusion (Adger, 2003). The following discussion will focus on the influences of these elements of social capital for the OWI and its adaptive capacity.

Cooperation and collective action underlie the social dynamics of adaptive capacity (Adger, 2003), expanding the resource base and problem solving capacity of the group (Grootaert et al., 2005). Participants from the OWI indicate there is a great deal of cooperation and collective action present within the industry, as people are currently willing and actively helping each other. For people to work cooperatively and collectively a level of trust is needed (Foxton & Jones, 2011). Trust can be a choice or a necessary dependency (Dudwick et al., 2006), such as when an organization represents the interests of a group of stakeholders. Within the OWI the majority of participants indicated they felt a sense of trust with fellow members. Statements relating to trust as a necessary dependency are unable to be assessed as these were removed at the request of the organizations.

Social networks are the pathways, which enable people to access resources and collaborate to achieve shared goals (Dudwick et al., 2006). They can be informal such as those arising from friendship, kinship or formal consisting of belonging to organizations (Plummer & Fitzgibbon, 2007). This resource is demonstrated when people help each other such as assisting with a harvest failure. In this study all participants were members

of grape and wine organizations (refer Section 3.2.3) indicating formal networks were present, hence only statements relating to informal networks were given to participants. Results indicate informal networks are present in the OWI.

Social cohesion and inclusion focus on the persistence of social bonds and their dual potential to include or exclude members of a community (Dudwick et al., 2006). Being socially excluded from a group, especially from decision making, increases the vulnerability of those excluded, reduces overall adaptive capacity (Adger, 2003; Wandel and Smit, 2006), and increases the risk of conflict between groups (Colletta, & Cullen, 2000). In this study the majority of participants did not feel excluded from industry event.

Social capital has been described as the necessary glue for adaptive capacity (Adger, 2003) providing the social dynamics that support adaptation. Participants in this study have identified the presence of the elements of social capital within the OWI. Elements of trust, cooperation and collective action appear to be well developed while social networks, closeness and inclusion would benefit from further development.

Section 4.2 Implications of Composite Analyses

The results of the eight determinants from the framework (Figure 2.5) have been presented and individually discussed to gain an in-depth understanding of how each influence adaptive capacity. However the eight determinants are not independent but interlinked and can reinforce or undermine each other. Tol and Yohe (2007) highlight these connections through the 'weakest link' hypothesis, where a significant weakness in one determinant can undermine the others, reducing overall adaptive capacity. They also show that strength in one determinant can compensate for the weakness in another, reducing the damage to overall capacity.

To understand which determinants may be limiting capacity within the OWI the response means for the eight determinants were descriptively compared. The first step to complete this task was to perform a Cronback's alpha test (Appendix 6) for statistical reliability (refer section 3.2.4) on the indicators within each determinant. Statistical reliability was established within each determinant allowing for a comparison of the means to be carried out. To complete this the mean responses for each of the indicators within each determinants was done. The indicator means were then bought together to give an overall mean for each determinant. Results for the composite analysis are shown in Figure 4.9 and Appendix 4. Figure 4.9 displays the means for all eight determinants, showing a range of means from 2.8 to 3.4. The scale for the graph comes from the Likert Scale used in the questionnaire. A mean of 3 for this research has been interpreted as neutral; neither agree nor disagree. The determinants with the lowest means sitting below 3 are technology and political. Those with the greatest means are perception, diversity and knowledge. Institutions, social capital and financial resources all remain in the middle sitting on or just above a mean of 3.

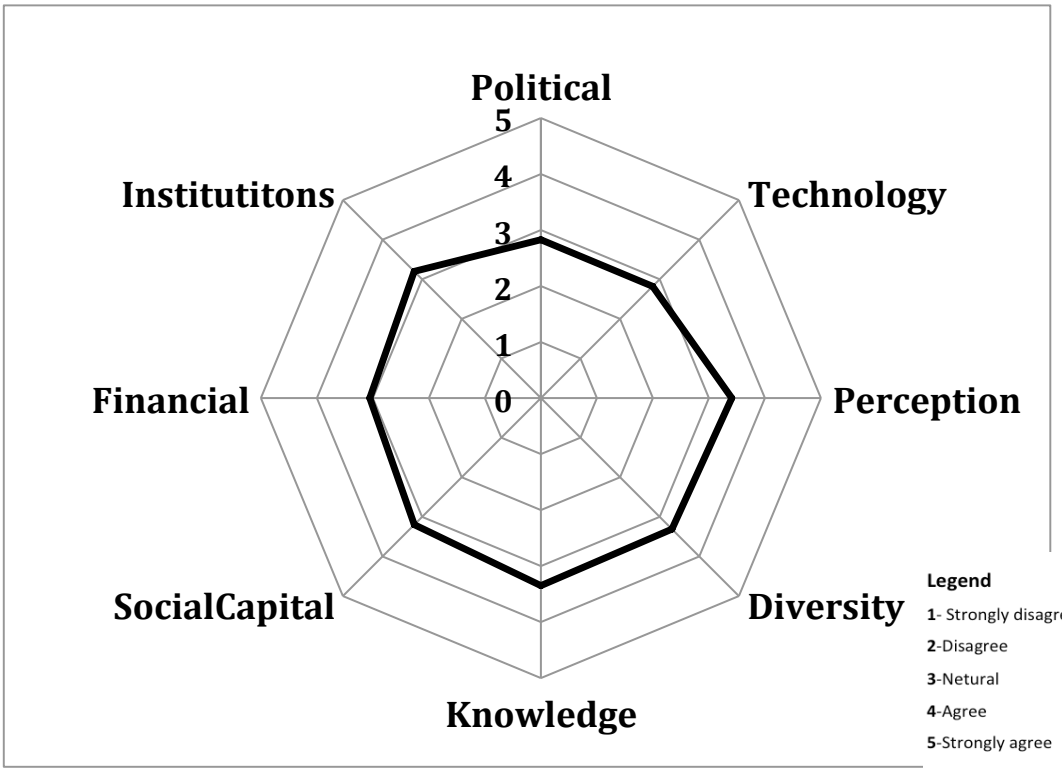


Figure 4.9 Means of the eight determinants of adaptive capacity for the OWI.

The following paragraphs will discuss what these results mean for the OWI. First, the results will be discussed in terms of the interrelationship between the determinants and how this influences the adaptive capacity of the industry. This will be followed by an exploration of the results in terms of their operational and strategic dimensions for the industry.

The results indicate the OWI has greater strength in the determinants of perception, diversity and knowledge. Overall industry members perceive there will be consequences for the industry from climate change and there is a strong interest to learn how to manage these events. This interest in change is supported by, and a consequence of, a belief they have not come to their threshold for coping with such events indicating there is capacity to plan strategically for managing future impacts. Further supporting this

capacity for learning and developing new management strategies are the level of access, sharing and valuing of both scientific and local knowledge present within the OWI. One of the key components to developing multiple, place specific, solutions is having access to knowledge types that members share and value (Reed, Dougill, & Taylor, 2007). Reduced dependency by stakeholders through diversity in skills and income further support this capacity to adopt new and innovative strategies (Marshall et al., 2007). All of these determinants work collectively in reinforcing and building capacity for the OWI to strategically move forward with climate change adaptions.

The political and technological determinants in Figure 4.9 have the lowest capacity. It is important to examine the interdependent relationship between these two resources and how the interplay between them can reduce or strengthen overall capacity. The importance of access-to and participation-in decision-making processes has already been identified as critical in building adaptive capacity (Adger et al., 2007). Decisions made outside the OWI affecting regulations and economic policies can limit the autonomy and options for climate change action by the industry. This was clearly demonstrate when producers were given economic incentives to replace cold resistant low quality grapes with market-driven tender varieties in response to the North American Free Trade Agreement (Belliveau, Smit, & Bradshaw, 2006). This varietal change improved the economic competitiveness of the industry but at the same time increased its susceptibility to climate change, as these grapes are very sensitive to cold temperatures. The major limiting factor for viticulture in Ontario is the cold temperatures. The development of new technologies such as wind machines presently helps in managing these tender varieties and as such indirectly supports the economic policy. However the

development of such technologies is reliant upon funding that maybe influenced by political goals other than those of interest to the OWI. An example of how funding can positively affect technological development is demonstrated by the success of the Cool Climate Oenology and Viticulture Institute at Brock University to develop multiple technologies to assist the OWI in managing climate change impacts from the Ontario Research Fund. If there had been a lack of interest or will to support the OWI in adapting to climate change the development of these technologies could have been delayed never realised further reducing the adaptive capacity of OWI. Hence the interdependent relationship between the political and technological determinants can either strengthen or weaken each other and the overall capacity of the OWI.

The determinants that pivot around the neutral mean of 3: institutions, social capital and financial resources also require a brief discussion. All of these determinants have a strong latent component to them in that they may not be realized or activated until an event occurs causing them to be mobilized. Within the institutional determinant the results show there is room for various types of leadership however these may not be activated or required until a need arises (Gupta et al., 2010). For example a leader with long-term vision may only come forth during a time when strategic and anticipatory plans are being developed. The resource is present but it only presents itself when the environment is receptive. This latency can also be seen within social capacity where elements such as cooperation, closeness and cohesion are often only activated when stressful events such as disasters occur (Adger, 2003). Again under the financial resources determinant the benefit of crop insurance and income stabilization plans are only realised when crop loses occur. Following crop losses in 2003 and 2005, over 90%

of those with insurance made a claim (Grape Growers of Ontario, 2012) indicating the resource was activated when it was required. The difficulty with insurance is that it is required before the crop loss occurs however the majority of respondents indicated they have resources to see them through bad years. Suffering one crop loss may be manageable for many stakeholders and may trigger the purchasing of crop insurance as it did in 2003 and 2005 (Grape Growers of Ontario, 2012).

Operational and Strategic Dimensions

The adaptive capacity framework developed for this research (see Figure 2.5) contains an inner circle categorizing the determinants as operational or strategic. Armitage (2005) defines operational determinants as those external factors that influence a system, but over which the system has limited control. These include financial, institutional, political and technological resources. Strategic dimensions include the determinants of adaptive capacity over which the industry has greater control. This includes social capital, perception, diversity and knowledge. In Figure 4.10 the determinant means (Figure 4.9) are presented in these categories for the purpose of identifying if there is a difference between the strategic and operational determinant categories. From Figure 4.10 it can be seen the determinants with the lowest means (political, technological) fall under the operational category where the OWI has less control. The stronger determinants (Knowledge, diversity, perception) dominate the strategic dimension. It is not surprising that the industry has greater capacity in the determinants that it controls. The industry can still influence operational determinants but being aware of limitations in influencing these determinants will help inform the industry as it develops a plan to move forward with climate change adaptation.

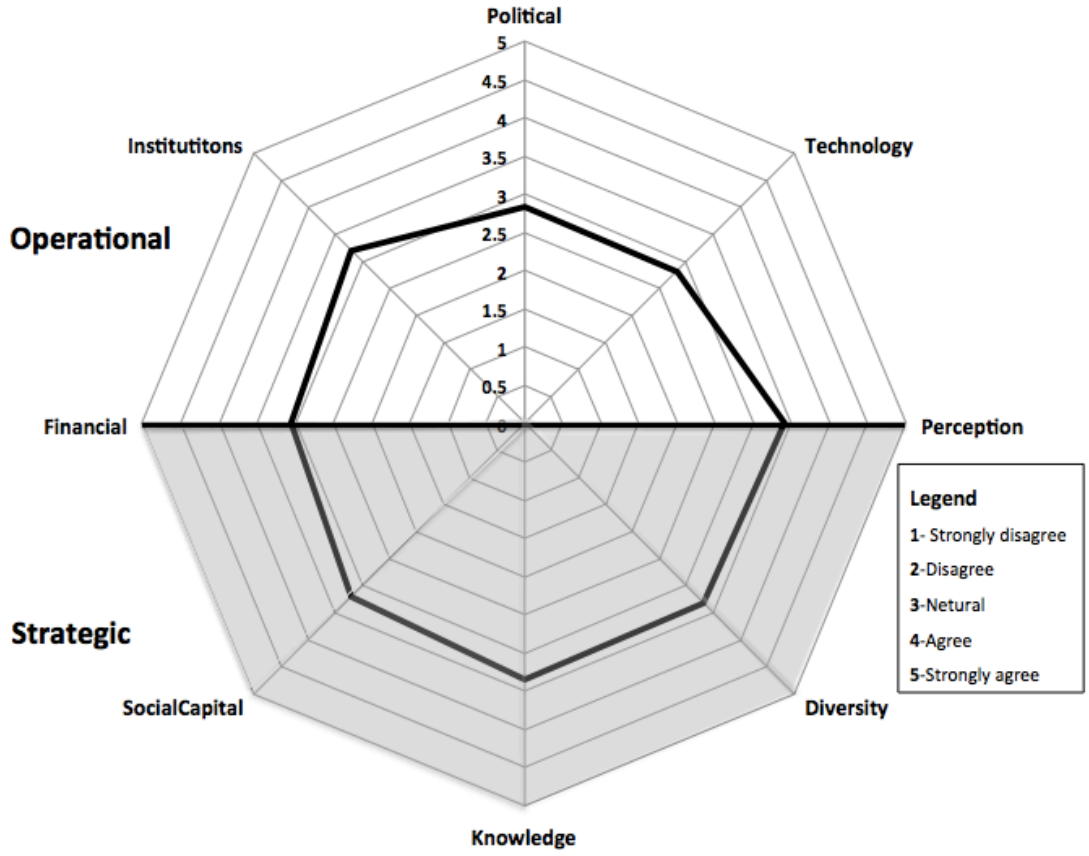


Figure 4.10. Composite analysis with operational and strategic dimensions

Section 4.3 Comparison of Grower and Wine Maker Responses

The two largest groups of stakeholders that make up the OWI are approximately 500 grape growers (Grape Growers of Ontario, 2012) and 130 wineries (Vintners Quality Alliance Annual Report, 2012). Many winemakers straddle both occupations growing their own grapes and making their own wine. Matheson, (2008), identified these groups had different perceptions and concerns regarding climate change impacts. As the main focus of this study was assessing the adaptive capacity of the industry, it is prudent to ensure there are no significant differences in responses to the questionnaire and determinants. Participation of these groups in this study consisted of grape growers (n=32), winemakers (n=8) which are representative of the actual populations within the

OWI. To explore if there was a statistical difference between the mean responses of growers and winemakers within each determinant, a one-way anova was performed (Appendix 7). Results indicate there was no significant difference between the two groups in their responses to the determinants.

Section 4.4 Summary

This chapter has presented the results of the assessment tool. An in-depth analysis and discussion has been given for each of the determinants. A composite analysis of the eight determinants was then completed to satisfy the second objective for this research to empirically assess the adaptive capacity of the OWI using the adaptive capacity framework. To determine if there was a difference in responses between grape growers and winemakers additional analysis was conducted. However, this did not show a statistically significant difference in responses between the two groups.

Chapter 5

Conclusion and Recommendations

Chapter Five provides a succinct summary of this study, communicates the salient contributions, and offers recommendations for both future research and the OWI. The chapter begins by revisiting the rationale and objectives that guided the project. A synopsis of the main findings is then offered and key insights are summarized. The contributions portion of the chapter highlights how the research has advanced scholarship and practice. In building upon these contributions the closing section offers recommendations for future research concerning conceptual development of adaptive capacity and applied considerations for the OWI.

5.1 Research Summary

The impacts of climate change are being experienced throughout the world. The agricultural sector is sensitive to change in climate and extreme weather events. Within the agricultural sector the global wine industry is especially susceptible to climate change, specifically extreme temperatures. The industry is already confined to narrow geographic bands in which the impacts of climate change are being experienced. This includes increasing frequency and intensity of extreme weather events, earlier growing seasons, changing precipitation patterns, and increasing pests and disease, all of which influence wine quality (Jones, 2005; Mira de Orduña, 2010).

The impacts of climate change are creating challenges to wine production in the OWI. Of most significance is the increasing potential for freeze damage to vines, delayed

and reduced icewine harvest, wetter falls and increasing presence of vineyard pests (Cyr, Kusy, & Shaw, 2010; Shaw, 2013). The industry is interested in adapting to these and other climate change impacts (Pickering, Pickering, Inglis, Shaw & Plummer, 2012). The process of adaptation is inextricably linked to the adaptive capacity of the OWI. Assessing the adaptive capacity can help to identify areas where capacity currently exists as well as where it is limited. Insights derived from such assessments permit important opportunities to enhance and/or build capacity in the short and long-term.

The main objective of this research was to assess the adaptive capacity of the OWI for climate change. Two objectives guided the research. The first objective sought to integrate the climate change literature relevant to adaptive capacity, oenology and viticulture and thereby develop a framework to assess adaptive capacity of the OWI. It was addressed through an extensive review of the climate change scholarly literature on adaptation, adaptive capacity and the international wine industry. This review did not reveal a comprehensive framework for assessing the many elements of adaptive capacity identified for the OWI. A framework was therefore developed by drawing upon aspects of the antecedent literature (Figure 2.5).

The second objective was to empirically assess the adaptive capacity of the OWI. It was undertaken using the assessment framework in objective one to guide the creation of an assessment tool in the form of a questionnaire. An invitation to voluntarily and anonymously complete this questionnaire on the Internet was sent to OWI members (growers, winemakers, supporting organizations) via the OWI supporting organizations (Grape Growers of Ontario, Wine Council of Ontario, Winery and Growers Alliance of

Ontario). Responses were then complied, analysed and interpreted to give an assessment of the present adaptive capacity of the OWI.

A synopsis of the main findings and insights from this study are summarized in Table 5.1. The findings from the research reveal that the OWI has a degree of capacity in all the resources assessed. The strategic determinants (categorised as those over which the industry has most control) overall show greatest capacity. Operational determinants (those over which the industry has less direct control) indicate more limited capacity. Column two in Table 5.1 identifies the eight adaptive capacity determinants (see Figure 2.5) that formed the assessment. The following column depicts the results of the analysis and indicates the present adaptive capacity of each determinant. Resources with greater capacity were perception, diversity and knowledge. Those identified with limited capacity are financial, institutional, political, technology and social capital.

Table 5.1 Summary of adaptive capacity assessment for the OWI

Type of determinant	Determinant	Main findings of Present Adaptive Capacity	Ways to Foster Adaptive Capacity
Operational The industry has less control	**Financial resources**	Limited use of crop insurance and income stabilization plans.	Educate stakeholders on the purpose of financial tools as a risk management strategy.
	Institutional	Limited access to infrastructure Limited access to policy options. High level of room for innovation and leadership	Continue communication between OWI and all government levels with an emphasis on water infrastructure and policy options. Maintain support for autonomy, learning and leadership within the industry.
	Political	Limited political support and connections. High level of political participation from stakeholders.	Industry representatives to continue advocating OWI needs to all levels of government to influence policies, support and connections. Keep stakeholders informed of all political progress. Create opportunities for stakeholders to politically participate in supporting the industry e.g. letters to MMP's on relevant issues.
	Technology	Greater incorporation of new technologies than recognized.	Continue with new technology research and further education of stakeholders on available technologies.
Strategic: The industry has greatest control	**Perception**	High degree of climate change perception and desire to learn new skills.	Use existing perception and interest in adapting to climate change to collectively develop and implement an adaptation plan.
	Diversity	High degree of income and skill diversity.	Encourage and support opportunities for income and skill diversity.
	Knowledge	High degree of local and scientific knowledge being accessed, shared, and valued.	Continue and extend present activities and modes for accessing and sharing knowledge. Maintain the value of knowledge through continued collaboration of industry stakeholders and researchers.
	Social Capital	Elements of trust, cooperation and collective action are well-established, social networks, inclusion and closeness more limited.	Support and encourage opportunities for stakeholders to build social networks, closeness and inclusion. Support opportunities to enhance trust, cooperation and collective action.

5.2 Contributions of this research

Several novel advancements stem from assessing the adaptive capacity of the OWI to climate change adaptation. This section highlights the main contributions from this research. Contributions are categorized and discussed in terms of furthering scholarship and application.

5.2.1 Conceptual Contributions

This study has made several contributions to the conceptual development of adaptive capacity. The main contribution and first to be discussed is the manner in which it brings together knowledge from different areas of scholarship to provide a wine industry assessment framework. An extensive amount of research exists on the present and future impacts of climate change for the wine industry, as demonstrated in Chapter 2. However, researchers have thus far done little to consolidate study findings and to synthesize them into more meaningful and usable tools for the wine industry. Industry researchers and stakeholders acknowledge this and are interested in adapting to climate change. Holland and Smit (2010) explicitly identify limited integration between the scholarship on impacts of climate change for wine industry and the process of adaptation and adaptive capacity to climate change. This research contributes to filling this knowledge void by integrating the climate change adaptive capacity scholarship with the concerns and interests of the wine industry to create an applied assessment framework that can be implemented to many wine regions. More specifically, the assessment framework developed (Figure 2.5) and employed in this research offers a conceptual contribution to the scholarly literature.

A criticism of adaptive capacity relates to its limited application to real world situations (Smit and Wandel, 2006; Gallopin, 2006; Engle, 2011). Previous studies have explored adaptive capacity in specific communities (Armtiage, 2005; Marshall, 2010; Wesche and Armitage, 2010). The second contribution of this is research is in its application of the concept within the broader context of the agricultural sector, specifically the OWI. This is the first time an in-depth assessment of the adaptive capacity of the OWI has been undertaken to date.

The climate change scholarship identifies many determinants that influence adaptive capacity (Table 2.2). The third scholarly contribution stemming from this study is the identification of determinants and indicators most relevant to the concerns and challenges of the wine industry (Table2.5). For example, financial resources have been defined as access to and availability of resources and their distribution across a population (Yohe & Tol, 2002). Financial determinants have previously been measured in several ways, such individual income levels and gross national product (Brookes, 2005). In building upon this general scholarship this research defined financial determinants as: access and availability to crop insurance, income stabilization programs, credit, and variability of income. Determinants of adaptive capacity become specific to the wine industry are thus advanced.

5.2.2 Applied Contributions

The scholarly advancements from this research are complemented by contributions to practice, specifically for the OWI. The assessment of adaptive capacity in this research gives a 'snapshot' of present capacity for the OWI and thus offers a baseline for future consideration. Baselines are essential for monitoring and tracking

changes and may be used to provide a comparison for assessing future outcomes or impacts (World Bank Institute, 2007). The OWI can revisit the initial assessment of adaptive capacity in the future, make comparisons, and have an empirical basis for judging success of actions and policies.

The assessment also affords the OWI valuable insights into its present adaptive capacity. Areas of strength and limitations are made clear and the factors influencing capacity are revealed. Information such as this can provide a starting point to discuss how adaptive capacity can be enhanced (Gutpa et al., 2010).

5.3 Recommendations

This study was an initial effort to assess the adaptive capacity of the OWI for adapting to climate change. Several recommendations emerge from the process of conducting the research as well as the findings. These recommendations address future research on adaptive capacity within the climate change scholarship as well as directions for the OWI.

Future research efforts should build on this study and go further. This research was exploratory. For this study three groups defined the OWI: grape growers ($n \leq 500$), wineries ($n \leq 130$), and supporting organization ($n = 18$). A questionnaire developed from the assessment framework (Figure 2.5) was made accessible to the OWI through the Selectsurvey.NET an online survey site. Several invitations to complete the survey were sent to OWI members. The response rate was 12%, and while consistent with expected response rates from Internet surveys (Poade, 2007), the researcher contacted organizations assisting with the research and asked about previous rates of responses. The organizations indicated that the response rate for the survey was in fact higher than

normal and suggested that participant fatigue might be a factor. An opportunity thus exists for future research to conduct an in-depth investigation by employing additional research methods, such as in-depth interviews.

This research was a single case study of the OWI. A multiple case study design could be undertaken within Ontario. It would permit identification and understanding of adaptive capacity and interplay between operational and strategic determinants in different places and according to industry maturity. More specifically, a multiple case study of the adaptive capacity of Niagara, an established wine area, compared with Prince Edward County, a developing region, could inform the understanding of how adaptive capacity develops. For example start-up grants available for developing regions may influence the development of adaptive capacity by affecting stakeholders' decisions to purchase crop insurance and income stabilization plans. Exploring these factors will further develop the elements affecting adaptive capacity.

Another future research opportunity is to expand the research beyond Ontario. Wine growing occurs globally and places of similar climate and topography are experiencing similar impacts as the OWI. A multiple case study involving international wine regions would provide an opportunity to explore if the OWI results can be replicated. Given the different political, cultural and geographical influences affecting adaptive capacity a study of this nature would highlight the determinants that are context specific and those which cut across particular circumstances.

For the OWI there are several recommendations that come from this research to enhance and build on present adaptive capacity. Overall, the OWI has varying amounts of capacity within all the areas assessed. Those areas where capacity is greater will benefit

from the continued support and encouragement of the OWI with present activities. For example many wineries now included restaurants and gift shops on the winery site, this building capacity through the diversification of income and skills. Efforts that support and encourage these activities through advertising, food and wine events, the culinary trail should continue. Recommendations to specific area have been summarised in the final column of Table 5.1.

Areas where capacity is more limited fall within the operational category, where the industry has less control. In this category a lack of recognition and understanding of the resources available to the industry was identified as significant in limiting capacity in these areas. For example more members were using new technologies such as early warning weather systems than perceived they had access to them. Increasing awareness of the resources available to members and how they can be utilized to build capacity is recommended.

Finally there is a strong interest within the OWI to learn ways to better adapt to climate change. This provides an opportunity to bring growers, winemakers and all supporting institutions together to begin the discussion of how the industry could strategically plan its future adaptation. Creating such collective action would build and strengthen present capacity further assisting the industry with adapting to climate change.

References

Adger, W. N. (2003). Social capital, collective action, and adaptation to climate change. *Economic geography*, *79*(4), 387-404.

Adger, N., Agrawala, S., Mirza, M., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit B., & Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity.In L. Parry, M., Canziani, O., Palutikof, J., van der Linden P., & Hanson, C. (Eds.). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp.717-743). Cambridge University Press, Cambridge, UK.

Adger, W.N., & Barnett, J. (2009). Reasons for concern about adaptation to climate change. *Environment and Planning*, (40), 2800-2805.

Adger, W.N., & Vincent, K. 2004. Uncertainty in adaptive capacity. External Geophysics, Climate and Environment, (337), 399-410.

AgriCorp. (2012). Production insurance. Retrieved from http://www.agricorp.com/en-ca/Programs/ProductionInsurance/Grapes/Pages/Overview.aspx

Alonso, A., & O'Neill, M. (2011). Climate change from the perspective of Spanish wine growers: a three-region study. *British Food Journal*. 113(2),205-221.

Argrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development Change*. (26),413-439.

Armitage, D. (2005). Adaptive capacity and community-based natural resource management. *Environmental Management*. 35(6),703-715

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change*. (18),86-98.

Armitage, D., & Plummer, R. (2010). Adapting and transforming: Governance for navigating change. In Armitage, D., & Plummer, R. (Eds.). *Adaptive Capacity and Environmental Governance* (pp. 287-302). Springer, Germany.

Bailey, C., & Pomeroy, C. (1996). Resource dependency and the development options in coastal Southeast Asia. *Society and Natural Resources*. (9),191-199.

Battaglini, A., Barbeau, G., Bindi, M., & Badeck, F. W. (2009). European winegrowers' perceptions of climate change impact and options for adaptation. *Regional Environmental Change*, *9*(2), 61-73.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: study design and implementation for novice researchers. The Qualitative Report. 13(4),544-559.

Beckford, C., & Barjker, D. (2007). The role and value of local knowledge in Jamaican agriculture: adaptation and change in small-scale farming. *The Geographical Journal*. 173(2),118-128.

Bélanger, G., Rochette, P., Castonguay, Y., Bootsma, A., Mongrain, D., & Ryan, D. (2002). Climate change and winter survival of perennial forage crops in eastern Canada. *Agronomy Journal*. 94(5),1120–1130. Doi:10.2134/agronj2002.1120

Belliveau, S., Smit, B., & Bradshaw, B. (2006). Multiple exposures and dynamic vulnerability: evidence from the grape industry in the Okanagan Valley, Canada. *Global Environmental Change*. 16:364-378

Berkes, F., Colding, F., & Folke, C. (2003). Synthesis: building resilience and adaptive capacity in social-ecological systems. In Berkes, F., Colding, J., & Folke, C. (Eds.). *Navigating social-ecological systems: building resilience for complexity and change* (pp. 25-57). Cambridge, New York : University Press

Bernardi, R. (1994). Validating research results when Cronbach's alpha is below 7.0: a methodological procedure. *Educational and Psychological Measurement*. 54(3),766-775. Available at SSRN: http://ssrn.com/abstract=1097125

Bohensky, E., Stone-Jovicich, S., Larson, S., & Marshall, N. (2010). Adaptive capacity in theory and reality: implications for governance in the Great Barrier Reef region. In Armitage D., & Plummer R. (Eds.). *Adaptive Capacity and Environmental Governance* (pp.23-42). Springer Heidelberg Germany.

Boyd, M., Pai, J., Qiao, Z., & Ke, W. (2011). Crop Insurance principles and risk implications for China. *Human and Ecological Risk Assessment*. (17),554-565. DOI: 10.1080/10807039.2011.571072.

Briggs, J. (2005). The use of indigenous knowledge in development: problems and challenges. *Progress in Development Studies*. (5),99-114.

Brooks, N. (2003). Vulnerability, risk and adaptation: A conceptual framework. *Tyndall Centre for Climate Change Research*. Working Paper 38. Retrieved from http://www.tyndall.ac.uk/sites/default/files/wp38.pdf

Brooks, N., & Adger, W.N., & Kelly, P.M. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change* (15),151–163

Brown, P., & Ward, J. (2011). Understanding constraints and opportunities of farmers for managing climate change; an integrated social-economic approach. CLUES Project. Retrieved from http://www.scribd.com/doc/104131691/P-Brown-J-Ward-SocioEconomics-Vietnam-Oct-2011.

Burton I. (2009). Deconstructing Adaptation…and Reconstructing. In Schipper, L., & Burton I. (Eds.). *The Earthscan Reader on Adaptation to Climate Change* (pp. 11-14). Earthscan, Dunstan House, London.

Chen, P.Y., & Krauss, A.D. (2004). Cronbach's Alpha. In Lewis-Beck, M., Bryman, S.A., & Liao, T.F. (Eds.). The Sage encyclopaedia of social science research methods. **DOI:** 10.4135/9781412950589 **Print ISBN:** 9780761923633 | **Online ISBN:** 9781412950589

Classon, D., & Dormody, T. (1994). Analyzing data measures by individual likert-type items. *Journal of Agricultural Education*. 35(4),31-36

Colletta, R., & Cullen, M. (2000). The nexus between violent conflict, social capital and social cohesion: case studies from Cambodia and Rwanda. Retrieved from Social Development Department, World Bank. http://siteresources.worldbank.org/INTSOCIALCAPITAL/Resources/Social-Capital-Initiative-Working-Paper-Series/SCI-WPS-23.pdf

Connolley, L. (2011). Cronbach's alpha. *MEDSURG Nursing*. 20(1),45.

Creasy, G. L., & Lombard, P. B. (1993). Vine water stress and peduncle girdling effects on pre-and post-veraison grape berry growth and deformability. *American journal of enology and viticulture*, *44*(2), 193-197.

Creswell, J. (1998). Research design: Qualitative, quantitative, and mixed methods approaches (2nd ed.). Thousand Oaks, CA: Sage.

Crimp, S. (2000). A capital concept of adaptive capacity. Climate: Ground Cover. Retrieved from http://www.grdc.com.au/Media-Centre/Ground-Cover-Supplements/~/media/7DFFD3C49C034C5F90611A95826D5432.pdf

Croasmun, J., & Ostrom, L. (2011). Using Likert-type scales in the social sciences. *Journal of Adult Education*. 40(1),19-23.

Crossman, N. & Bryan, B. (2009) Identifying cost-effective hotspots for restoring natural capital and enhancing landscape multifunctionality. Ecological Economics. (68), 654-668.

Cyr, D., & Shaw, T. (2010). The impact of global warming on Ontario's icewine industry. *VIII International Terroir Congress, Proceedings Session 3*. (pp. 9-16). http://terroir2010.entecra.it/atti/index.html

Dawes, J. G. (2008). Do data characteristics change according to the number of scale points used? An experiment using 5 point, 7 point and 10 point scales. *International Journal of Market Research.* 51(1), 61-77.

Diffenbaugh, N., White, M., Jones, G., & Ashfag, M. (2011). Climate adaptation wedges: a case study of premium wine in the western United States. *Environmental Research* Letters. (6), 1-11.

Dudwick, N., Kuehnast, K., Nyhan Jones, V., & Woolcock, M. (2006). Analyzing social capital in context: A guide to using qualitative methods and data. *The International Bank for Reconstruction and Development: The World Bank*. Stock No.37260.

Dunchene, E., & Schneider, C. (2005). Grapevine and climate changes: a glance at the situation in Alsace. *Sustainable Development*. (24), 93-99.

Eakin, H., & Bojorquez-Tapia, L. (2008). Insights into the composition of household vulnerability from multicriteria decision analysis. *Global Environmental Change*. 18(1), 112-127.

Eakin, H., & Lemos, M. (2006). Adaptation and the state: Latin America and the challenge of capacity-building under globalization. *Global Environmental Change*. (16), 7-18.

Engle, N., & Lemos, M. (2007). Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change*. (20),4-13.

Engle, N. (2011). Adaptive capacity and its assessment. *Global Environmental Change*. (21), 647-656.

Eriksen, S. (2004). Building adaptive capcity in a 'glocal' world: examples from Europe and Africa. Centre for International Climate and Environmental Research. 2(2), 18-27.

Folke, C., Colding, J., & Berkes, F. (2003). Synthesis: building resilience and adaptive capacity in social-ecological systems. In Berkes, F., Colding, J., & Folke, C. (Eds.), *Navigating social-ecological systems: building resilience for complexity and change* (pp. 376-407). Cambridge, New York : University Press.

Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*. (16), 253-267

Ford, J., Smit, B., & Wandel, J. (2006). Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change*. (16),145-160.

Foxton, F. & Jones, R. (2011). Social Capital Indicators Review. *Office for National Statistics.* United Kingdom Government. Retrieved from *www.ons.gov.uk/ons/dcp171766_233738.pdf*

Fraser, H. (2012). Wind machines for minimizing cold injury to horticultural crops. Retrieved from http://www.omafra.gov.on.ca/english/engineer/facts/10-045.htm .

Fraser, H., Slingerland, K., Ker, K., Fisher, H., & Brewster, R. (2009). Reducing cold injury to grapes through the use of wind machines: Final Report: CanAdvance Project # ADV – 161. Retrieved from *www.omafra.gov.on.ca/english/crops/hort/.../tf1403a3.htm*

Füssel, H. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*. (17),155-167.

Füssel, H. (2009). An updated assessment of the risks from climate change based on research published since the IPCC Fourth Assessment Report. *Climatic Change*. (97), 469-482.

Gadgil, M., Olsson, P., Berkes, F., & Folke, C. (2003). Exploring the role of local ecological knowledge in ecosystem management: three case studies. In Berkes, F., Colding, J., & Folke, C. (Eds.), *Navigating social-ecological systems: building resilience for complexity and change* (pp. 213-233). Cambridge, New York : University Press.

Gallopin, G. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*. (16), 293-303

Gerring, J. (2007). Case Study Research: Principles and Practices. Cambridge, Cambridge University Press.

Government of Canada. (2010). Status of climate change adaptation in Canada's agricultural sector: Research paper. Eds. Jacques, L-S., De Vit, C., & Gagnon-Lebrun, F. http://www.horizons.gc.ca/doclib/2010-0040_eng.pdf

Grape Growers of Ontario. (2011). Annual report. Available at *www.**grapegrowersofontario**.com/**annual-reports***

Gilby, C. (2005). "Global warming- a hot topic for viticulture". Retrieved from www.winepages.com/guests/caroline/globalwarming.htm

Grothman, T., & Pratt, A . (2003). Adaptive capacity and human cognition. Open meeting of the Global Environmental Change Research Community, Montreal, Canada, October 16-18.

Grootaert, C. Narayan, D. Nyhan Jones, V. & Woolcock, M. (2004) Measuring Social Capital: An integrated questionnaire. World Bank Working Paper No. 18. ISBN 0-8213-5661-5

Gunderson, L. (2003). Adaptive dancing: interactions between social resilience and ecological crises. In Berkes, F., Colding, J., & Folke, C. (Eds.), *Navigating social-ecological systems: building resilience for complexity and change* (pp.57-76). Cambridge, New York : University Press.

Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van der Brink, M., Jong, P., Nooteboom, S., & Bergsma, E. (2010). The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy. (*13), 459-471.

Hadarits, M., Smit, B., & Diaz, H. (2010). Adaptation in viticulture: A case study of producers in the Maule Region of Chile. *Journal of Wine Research*. 21(2-3),167-178.

Haddad, B. (2005). Ranking the adaptive capacity of nations to climate change when socio-political goals are explicit. *Global Climate Change*. (15),165-176.

Hinkel, J. (2011). Indicators of vulnerability and adaptive capacity: Towards a clarification of the science-policy interface. *Global Environmental Change*. (21),198-208.

Holling, C.S. (1973). Resilience and stability of ecological systems. *Annual Reviews Ecological Systems*. (4),1-13.

Holland, T., & Smit, B. (2010). Climate change and the wine industry: Current research themes and new directions. *Journal of Wine Research*. 21(2-3), 125-136.

Jamieson, S. 2004. Likert Scales: how to (ab)use them. Medical Education. 38:1212-1218.

Johansson, R. (2003). Case study methodology. International Conference "Methodologies in Housing Research. www.infra.kth.se/bba/IAPSPDF/paperRolfJohanssonver2.pdf

Johnston M., Williamson, T., Wheaton, E., Wittrock, V., Nelson, H., Hesseln, H., Vandamme, L., Pittman, J., & Lebel, M. (2008). Climate change adaptive capacity of forestry stakeholders in the Boreal Plains ecozone. . Government of Canada Climate Change Impacts and Adaptation Program. Project A1383. Smart Science Solutions No. 12306-3C08. Retrieved from *cfs.nrcan.gc.ca/publications?id=33429*

Jones G., White, M., Cooper, O., & Storchmann, K. (2005). Climate change and global wine quality. *Climatic Change.* (73), 319-343.

Jones, G. (2010). Climate change and the global wine industry. *Thirteenth Australian Wine Industry Technical Conference.* (pp. 1-8). Retrieved from http://www.sou.edu/envirostudies/gjones_docs/AWITC%20GJones.pdf

Ladányi, M., Hlaszny, E., Pernesz, Gy., & Biszztray, Gy. (2010). Climate change impact study based on grapevine phenology modelling. *VIII Internation Terrori Congress.*

Proceedings Session 3 (pp. 65- 71). Retrieved from http://terroir2010.entecra.it/atti/index.html

Lebel, L., Anderies, J.M., Campbell, B., Folke, C., & Hatfield-Dodds, S. (2006). Governance and the capacity to manage resilience in regional social-ecological systems. Marine Science Faculty Scholarship. Paper 52. Retrieved from http://digitalcommons.library.umaine.edu/sms_facpub/52

Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2007). Playing it forward: Path dependency, progressive incrementalism, and the 'Super Wicked' problem of global climate change. In *International Studies Association 48th Annual Convention, February* (28).

MaaB, U., & Schwab, A. (2010). "Terroir" and climate change in Franconia/Germany. *VIII Intenrational Terroir Congress. Proceedings Session 3* (pp. 58-61). Retrieved from http://terroir2010.entecra.it/atti/index.html

Maddrell A. (2009). History of Geography. In Kitchin, R., & Thrift, N.(Eds) *International Encyclopedia of Human Geography*. (pp.415-428). Elsevier, *2009*. ISBN, 0080449115

Malheiro, A.C., Santos, J.A., Fraga, H., & Pinto, J.G. (2010). Future scenarios for viticulture climatic zoning in Europe. *VIII International Terrior Congress. Proceedings Session 3* (pp. 90-95). Retrieved from http://terroir2010.entecra.it/atti/index.html

Matheson, L. (2008). The grape debate: adapting to climate change in the Niagara grape and wine industry. Master's thesis. University of Guelph

Matthews, R., & Sydneysmith, R. (2010). Adaptive capacity as a dynamic institutional process: Conceptual perspectives and their application. In Armitage, D., & Plummer, R.

(Eds.) *Adaptive Capacity and Environmental Governance*. Springer Heidelberg Germany.

Mahul, O., & Stutley, C. (2010). Annex E: International Experiences with Agricultural Insurance: Findings from a World Bank Survey of 65 Countries. *Government Support to Agricultural Insurance: Challenges and Options for Developing Countries*. Retrieved from http://www.siteresources.worldbank.org%2FFINANCIALSECTOR%2FResources%2FCountryOverviewMasterPiece_final_ANNEX_E.pdf

Marshall, N., & Marshall, P. (2007). Conceptualizing and operationalizing social resilience within commercial fisheries in Northern Australia. *Ecology and Science*. 12(1),1

Marshall, N., Fenton, P., Marshall, P., Sutton., S. (2007). How resource dependency can influence social resilience within a primary resource industry. Rural Sociology. 72(3), 359-390.

Marshall, N. (2010). Understanding social resilience to climate variability in primary enterprises and industries. *Global Environmental Change*. (20),36-43

Matell, M. S., & Jacoby, J. (1971). Is there an optimal number of alternatives for Likert Scale items? I. Reliability and validity. *Educational and psychological measurement*.

Menny, C., Osberghaus, D., Pohl, M., & Werner, U. (2011). General knowledge about climate change, factors influencing risk perception and willingness to insure, ZEW Discussion Papers, No. 11-060. Retrieved from http://hdl.handle.net/10419/51357

Mira de Orduña, R. (2010). Climate change associated effects on grape and wine quality and production. *Food Research International*. (43), 1844-1855.

Moser, S. & Ekstrom, J. (2010). A framework to diagnose barriers to climate change adaptation. Proceedings of the National Academy of Science. *doi:10.1073/pnas.1007887107*

Mulder, K., Troy, A., & Boumans, R. (2006). The role of built, human, social, and natural capital in determining land values, and the influence of demographics upon this relationship. Spatial Economic Analysis. 2(2), 135-157.

Natural Resources Canada (NRCA): Climate Change Impacts and Adaptation. (2007). Climate change impacts and adaptation: a Canadian perspective. Eds Lemmen, D., & Warren, F. Natural Resources Canada, Ottawa, Ontario. ISBN: 0-66-33123-0. http//adapatation.nrcan.gc/perspective_e.asp

Nelson, R., Kokic, P., Elliston., & King, J. (2005). Structural adjustment: a vulnerability index for Australian broadacre agriculture. Australian Commodities. 12(1) 171-180.

Nelson, D., Adger, N., & Brown, B. (2007). Adaptation to environmental change: Contributions of a resilience framework. *Annual Review of Environmental Resources*. (32), 395-419.

Nelson, R., Kokic, P., Crimp, S., Meinke, H., & Howden, S. (2010). The vulnerability of Australian rural communities to climate variability and change: Part 1- Conceptualising and measuring vulnerability. *Environmental Science & Policy*. (13),8-17.

Nooteboom, S.G. (2006) Adaptive networks. The governance for sustainable development. Eubron, Delft.

Ontario Ministry of Agriculture and Food and Rural. (2011). Climate Change and agriculture. http://www.omafra.gov.on.ca/english/engineer/facts/climatechange.htm

Organization for Economic Cooperation and Development. (2001). The well-being of nations: The role of human and social capital. Centre for Educational Research and Innovation, OECD, Paris.

Pearse, N. (2011). Deciding on the scale granularity of response categories of Likert type scales: The case of a 21-point scale. *Electronic Journal of Business Research Methods*. 9(2),159-171.

Pelling, M., & High C. (2005). Understanding adaptation: What can social capital offer assessments of adaptive capacity? *Global Environmental Change*. (15)308-319.

Phillips, R. (2000). A short history of wine. Allen Lane. The Penguin Press. London , England.

Pickering, G. J., Blake, A. J., Soleas, G. J., & Inglis, D. L. (2010). Remediation of wine with elevated concentrations of 3-alkyl-2-methoxypyrazines using cork and synthetic closures. *Journal of Food, Agriculture & Environment*, *8*(2), 97-101.

Pickering, G. J., Heatherbell, D. A., & Barnes, M. F. (1999). The production of reduced-alcohol wine using glucose oxidase-treated juice. Part III. Sensory. *American journal of enology and viticulture*, *50*(3), 307-316.

Pickering, G. & Lin, J. (2006). Asian Lady Beetle (*Harmonia axyridis*) and wine quality. IN: Dris, R(ed.) Crops:Growth, Quality & Biotechnology. III. Quality Management of Food Crops for Processing Technology. WFL Publisher, Meri-Rastilan tie 3 C, Helsinki, Finland, 778-784. ISBN 952-91-8601-0.

Pickering, K., Pickering, G., Inglis, D., Shaw, T., & Plummer, R. (2012). Innovation and adaptation in the Ontario grape and wine industry: An integrated, transdisciplinary response to climate change. Environmental Sustainability Research Centre. Working Paper series. URI: http://hdl.handle.net/10464/4149

Plummer R., & Armitage D. (2010). Integrating perspectives on adaptive capacity and environmental governance. In Armitage D., & Plummer R. (Eds.). *Adaptive Capacity and Environmental Governance* (pp.1-22).Springer Heidelberg Germany.

Plummer, R., & FitzGibbon, J. (2007). Connecting adaptive co-management, social learning, and social capital through theory and practice. *Armitage, D., Berkes, F., and N. Doubleday. Adaptive Co-Management: Collaboration, Learning and Multilevel Governance. UBC Press: Vancouver, BC*, 38-61.

Poade, D. (2007). Sampling and response: The experience of conducting an online student survey presentation. www.research.plymouth.ac.uk/methodologicalinnovations/Methods07/Presentations/poade.pps

Qian, B., Gamda, S., Zhang, X., & De Jong, R. (2012). Changing growing season observed in Canada. *Climate Change*. (112) 339-353.

Ramos, M.C., & Martinez-Casanovas, C. (2010). Climate variability and its effects in the Penedès vineyard region. *VIII International Terrior Congress. Proceedings Session 3.* (pp. 23-28). Retrieved from http://terroir2010.entecra.it/atti/index.html

Reed, M. S., Dougill, A. J., & Taylor, M. J. (2007). Integrating local and scientific knowledge for adaptation to land degradation: Kalahari rangeland management options. *Land Degradation & Development*, *18*(3), 249-268.

Rittel, H., & Webber, M. (1973).Dilemmas in a General Theory of Planning. *Policy Sciences*. (4) 155-169.

Rosenzweig, C., G. Casassa, D.J., Karoly, A., Imeson, C., Liu, A., Menzel, S., Rawlins, T.L., Root, B., Seguin, P., & Tryjanowski, (2007). Assessment of observed changes and

responses in natural and managed systems. In. Parry, M.L., Canziani, O.F., Palutikof, . J.P., van der Linden P.J., & Hanson, C.E. (Eds.) *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, (pp79-131). Cambridge University Press, Cambridge, UK.

Saint-Ges, V., & Bélis-Bergouignan, M. (2009). Ways of reducing pesticides use in Bordeaux vineyards. *Journal of Cleaner Production*. (17), 1644-1653.

Schultz, H.R., & Jones, G.V. (2010). Climate induced historic and future changes in viticulture. *Journal of Wine Research*. 21(2-3), 137-145.

Schultz, H.R., & Stoll, M. (2010). Some critical issues in environmental physiology of grapevines: future challenges and current limitations. *Australian Journal of Grape and Wine Research.* (16),4-24.

Schwab, A., & MaaB, U. (2010). Climate Change - Variety Change? *VIII International Terroir Congress. Proceedings Session 3* (pp. 62-64). Retrieved from http://terroir2010.entecra.it/atti/index.html

Shaw, T. 2005. The Niagara Peninsula viticultural area: A climatic analysis of Canada's largest wine region. Journal of Wine Research. (16) 2: 85-103.

Shaw, T. 2013. Climate Change in established and emerging wine regions of Ontario: Risks and opportunities. Cool Climate Oenology and Viticulture Institute, Presentation March 6, 2013. Available from https://www.brocku.ca/webfm_send/25500

Shaw, T., & Cyr, D. 2010 The implications of climate change for the Ontario wine industry. Cool Climate Oenology and Viticulture Institute lecture series. http://brocku.ca/webfm_send/15848

Sherrick, B., Barry, P., Ellinger, P., & Schnitkey, G. (2004). Factors influencing farmers crop insurance decisions. *American Agricultural Economics Association*. 85(1),103-114

Smit, B. & Pilifosova, O. (2001). Adaptation to climate change in the context of sustainable development and equity. In: McCarthy, J. Canzianni, O. Leary, N. Dokken, D. White, K. (Eds), *Climate Change 2001: Impacts, Adaptation, and Vulnerability – Contribution of Working Group II Report of the Intergovernmental Panel on Climate change* (pp.876-912) Cambridge University Press, Cambridge.

Smit B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change.* (16), 282-292.

Smith, J., Schneider B., Oppenheimerd, M., Yohe, G., Haref, W., Mastrandreac, M., Patwardhang, A., Burton, I., Corfee-Morloti, J., Magadzaj, C., Füssel, H., Barrie Pittockk, A., Rahmanl, A., Suarezm, A., & van Yperselen, J. (2009). Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) "reasons for concern". PNAS. 106(11) 4133-4137

Smithers, J., & Smit B. (1997). Human adaptation to climate variability and change. *Global Environmental Change*. 7(2), 129-146.

Stake, R.E. (1995). The art of case study research. Thousand Oaks, CA: Sage.

Streiner D., & Norman G. (1989). Health measurement scales a practical guide to their development and use. New York: Oxford University Press (pp. 64-65).

Swanson, D. Hiley, J. Venema, H. D., & Grosshas, R. (2009). Indicators of adaptive capacity to climate change for agriculture in the Prairie region of Canada: Comparison with field observations. Working paper for the Prairie Climate Resilience Project,

Tierney, K., Bevc, C., & Kuligowski, E. (2006). Metaphors matter: disaster myths, media frames, and their consequences in Hurricane Katrina. The Annals of theAmerican Academy of Political and Social Science (604), 57-81.

Tol, R.S., & Yohe, G.W. (2007). The weakest link hypothesis for adaptive capacity: an empirical test. *Global Environmental Change*. (17), 218-227

The Grower. (2010). Wind machines earn anew respect in protecting apple crops. Retrieved from http://www.thegrower.org/readnews.php?id=9a2c7l1n6y8n

Vintners Quality Assurance. (2011). Map of wine growing appellations in Ontario. Retrieved from http://www.vqaontario.com/Appellations

Vuković, A., Vujadinović, M., Djurdjević, V., Ranković-Vasić, Z., Marković, N., Atanacković, Z., Sivčev, B., & Petrović. (2010). Appliance of climate projections for climate change study in Serbian vineyard regions. *VIII International Terroir Congress. Proceedings 3* (pp. 36-41). Retrieved from http://terroir2010.entecra.it/atti/index.html

Walker, B., Gunderson, L., Kinzig, A., Folke, C. ,Carpenter, S., & Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience on social-ecological systems. *Ecology and Society*. 11(1),13.

Wall, E., & Marzall, K. (2006). Adaptive capacity for climate change in Canadian rural communities. Local Environment. 11(4), 373-397

Weaver, R. (1976). Grape growing. Wiley and Sons. New York

Webb, L., Whetton, P., & Barlow, E. (2007). Modelled impacts of future climate change on the phenology of wine grapes in Australia. *Australian Journal of Grape and Wine Research*. 13(3), 165-175.

Wei, Y., Langford, J., Willet, I., Snow, B., & Lyle, C. (2011). Is irrigated agriculture in

the Murray Darling Basin well prepared to deal with reductions in water availability? *Global Environmental Change.* (21), 906-916.

Wesche S., & Armitage D. (2010). From the inside out: A multi-scale analysis of adaptive capacity in a northern community and the governance implications. In Armitage D., & Plummer R. (Eds.). *Adaptive Capacity and Environmental Governance*. Springer, Heidelberg Germany.

White, J. (n.d) Why buy crop insurance? Horticultural Business management http://hortmgt.dyson.cornell.edu/pdf/risk_mgt/newsletters/Why_buy_crop_insurance.pdf

Wollan, D. (2010). Membrane and other techniques for the management of wine composition. In Reynolds, A. (Edit.), *Managing wine Quality*, *Vol 2*. (pp.133-163). Woodhead Publishing Limited, Cambridge.

World Bank Institute. (2007). Monitoring & evaluating for results: Reconstructing baseline data for monitoring and evaluation-data collection methods. Retrieved from http://siteresources.worldbank.org/INTUKRAINE/Resources/328335-1212401346836/2BaselineReconstruction.pdf

Yin, R. K. (2008). *Case study research: Design and methods* (Vol. 5). Sage Publications, Incorporated.

Yohe, G. & Tol, R. (2002). Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. *Global Environmental Change-Human and Policy Dimensions* 12(1), 25–40.

Yohe, G & Tol, R, (2007). The weakest link hypothesis for adaptive capacity: An empirical test. *Global Environmental Change*. (17), 218-227

Brock University
Research Ethics Office
Tel: 905-688-5550 ext. 3035
Email: reb@brocku.ca

Social Science Research Ethics Board

Certificate of Ethics Clearance for Human Participant Research

DATE: 5/31/2012

PRINCIPAL INVESTIGATOR: SHAW, Tony - Geography

FILE: 11-270 - SHAW

TYPE: Masters Thesis/Project STUDENT: Kerrie Pickering
SUPERVISOR: Tony Shaw

TITLE: The adaptive capacity of the Ontario Wine Industry for climate change adaptation

ETHICS CLEARANCE GRANTED

Type of Clearance: NEW Expiry Date: 5/31/2013

The Brock University Social Sciences Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 5/31/2012 to 5/31/2013.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 5/31/2013. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at http://www.brocku.ca/research/policies-and-forms/research-forms.

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
c) New information that may adversely affect the safety of the participants or the conduct of the study;
d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Appendix B- Participation Consent Form

Consent Form

Date: **June, 2012**

Project Title: The adaptive capacity of the Ontario wine industry for climate change adaptation.

Principal Investigator (PI): **Tony Shaw, Associate Professor**

Department of Geography

Brock University

905 688-5550 ext

Email: tshaw@brocku.ca

Student Principal Investigator (SPI): **Kerrie Pickering,** MA Candidate

Department of Geography

Brock University

Email: kp02ad@brocku.ca

INVITATION

You are invited to participate in a study that involves research. The purpose of this study is to explore the adaptive capacity of the Ontario wine industry for climate change adaptation.

WHAT'S INVOLVED

As a participant, you will be asked to complete a questionnaire related to your occupation within the Ontario wine industry. Participation will take approximately 20 minutes of your time.

POTENTIAL BENEFITS AND RISKS

Participation provides an opportunity to express your views on the present adaptive strategies employed for extreme weather events within the Ontario wine industry and to offer input into the ways these strategies may be improved or made more accessible. Through this information there is the potential for other

growers and wine makers to benefit as new strategies are developed and offered to the industry. There are no known or anticipated risks associated with participation in this study.

CONFIDENTIALITY

Your name will not appear in any report resulting from this project; however, anonymous quotations may be used. The name of the organization represented if it is the Grape Growers of Ontario, Wine Council of Ontario, Winery & Growers Alliance of Ontario, or the Vintners Quality Assurance Board will be the only organizations explicitly named in the resulting reports and publications, while pseudonyms/descriptors will be used for individuals from these organizations.

Data collected during this study will be stored in a locked storage cabinet; any computer data will be stored only on the principal student investigators computer under password protection. Data will be kept for approximately one (1) year following the release of a final report after which computer data will be erased and any hardcopy materials shredded. Access to this data will be restricted to the principal investigator, student principal investigator and co-investigators: Tony Shaw and Kerrie Pickering.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. If you choose not to complete the questionnaire you may just exit the program. Further, you may decide to withdraw from this study at any time and may do so without any penalty. Incomplete questionnaire will not be retained.

PUBLICATION OF RESULTS

Results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available from Tony Shaw or Kerrie Pickering via telephone and email.

Tony Shaw, Department of Geography, Brock University,

tshaw@brocku.ca (905) 688-5550 ext. 3866

Kerrie Pickering, Department of Geography, Brock University,

kp02ad@brocku.ca (905) 401 7162

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please contact Tony Shaw or Kerrie Pickering using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University **(11-270-SHAW).** If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca.

Thank you for your assistance in this project.

CONSENT FORM

I agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I

wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

*◯ Yes *◯ No

Appendix C – Questionnaire: Adaptive Capacity Statements

Statements	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Finance					
I rely on crop insurance to get me through bad years					
I rely on credit to get me through bad years					
I have access to financial resources to keep going					
There is great variability in my monthly income					
There is great variability in my annual income.					
I use income stabilization programs to reduce variability in my income.					
Institutions					
The OWI invites a diverse range of stakeholders to be part of creating solutions for managing extreme weather events.					
There is a wide range of policy options available to tackle the impacts of extreme weather events and climate change for the OWI.					
Changes to improve present viticulture practices are encouraged by the OWI.					
Implementing new techniques in the vineyard is encouraged by the OWI					
I have access to infrastructure to get water for irrigation.					
There is room for leaders in the industry that stimulate long-term vision toward managing the impacts of extreme weather events and climate change.					
There is room for leader in the industry that stimulate action..					

There is room in the industry that stimulate collaboration…					
There is room in the industry that stimulate an entrepreneurial…					
Technology					
A lack of access to new technologies prevents me from implementing changes in the vineyard, in anticipation of climate change.					
I use early warning weather systems as part of my vineyard management practices.					
Political					
I believe the wine industry has political support in Ontario.					
I believe the wine industry has political support in Canada.					
I believe the wine industry has political connections that it can use for getting political action.					
I participate in political events (e.g. writing letters, sign petitions) related to the Ontario wine industry when the opportunity arises.					
Perception					
I believe climate change will positively affect the vineyard.					
I believe climate change will negatively affect the vineyard.					
I am used to bad years and I know I will survive future extreme weather events.					
I am interested in learning new skills outside the industry.					
I am interested in learning how I could better prepare for extreme weather events.					
I am interested in learning how I could better prepare for climate change.					
Diversity					
I rely on income sources other than grapes					

I have income sources outside of grape growing available, if I choose to use them.					
Due to my skill set I have many career options available to me if I decide to no longer be a wine grape grower.					
Knowledge					
I have access to local knowledge to help me manage the impacts of extreme weather events.					
I have access to scientific local knowledge to help me manage the impacts of extreme weather events.					
There is a sharing of local knowledge among grape growers within the Ontario wine industry.					
There is a sharing of scientific knowledge among grape growers within the Ontario wine industry.					
There is a sharing of local knowledge within the Ontario wine industry.					
There is a sharing of scientific knowledge within the Ontario wine industry.					
Local knowledge is valuable in my management of extreme weather events impacts.					
Scientific knowledge is valuable in my management of extreme weather events impacts.					
I have a viticulture/oenology certificate, diploma or degree.					
Social Capital					
Most people in the industry are willing to help you, if you request it.					
Growers within the Ontario wine industry help each other at present.					
I talk to other growers at least once a week.					

If I have a harvest failure there are people within the industry who would be willing to assist me (e.g. unpaid labor).					
Most people in the Ontario wine industry can be trusted.					
There is a strong sense of closeness (sticking together) in the Ontario wine industry.					
There are now wine industry events I am excluded from attending.					
I attended the GGO/WCO/WGOA AGM this year					

Appendix D- Cronbach's Alpha Table

Determinant	Indicator	Cronbach's Alpha
Financial resources	Availability and access to financial resources. Income variability Income stabilization	.637
Institutions	Collaborative decision-making Multiple solutions Infrastructure Leadership Innovation Learning	.752
Political	Provincial and National political support Political connections Political participation	.788
Technology	Availability and access to technology Incorporation of new technology	.62 given there are only 2 items this result is reasonable and there is a correlation of .45 making this acceptable.
Perception	Perceived risks of climate change Ability to cope with future events Interest in change	.886
Diversity	Diversity in income Diversity of skill set	.669
Knowledge	Accessibility to local and scientific knowledge Sharing of local and scientific knowledge Value of local and scientific knowledge	.941
Social Capital	Trust Networks Collective action Cohesion Inclusion	.920

Appendix E - One Way Anova Table

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Financial	Between Groups	.015	1	.015	.023	.881
	Within Groups	25.621	39	.657		
	Total	25.636	40			
Institutions	Between Groups	.059	1	.059	.071	.791
	Within Groups	32.577	39	.835		
	Total	32.637	40			
Technology	Between Groups	1.818	1	1.818	1.561	.219
	Within Groups	45.402	39	1.164		
	Total	47.220	40			
Political	Between Groups	.107	1	.107	.119	.732
	Within Groups	35.006	39	.898		
	Total	35.113	40			
Perception	Between Groups	.012	1	.012	.014	.905
	Within Groups	32.153	39	.824		
	Total	32.165	40			
Diversity	Between Groups	1.352	1	1.352	1.168	.287
	Within Groups	45.142	39	1.157		
	Total	46.493	40			
Knowledge	Between Groups	2.111	1	2.111	1.636	.208
	Within Groups	50.318	39	1.290		
	Total	52.429	40			
SocialCapital	Between Groups	1.739	1	1.739	1.426	.240
	Within Groups	47.563	39	1.220		
	Total	49.302	40			